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DEPARTMENT OF COMMERCE

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INFORMATION CIRCULAR

PHOSPHATE ROCK

PART I - GENERAL INFORMATION

BY

BERTRAND L. JOHNSON

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PART I. GENERAL INFORMATION

By Bertrand L. Johnson[2]

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DEFINITION

Phosphate rock is a general name applied to certain rocks of different degrees of consolidation and of diverse origins, characters, and modes of occurrence, composed of intimate mixtures of various allied amorphous or rarely crystallized phosphate minerals, usually calcium phosphates, with various impurities. Included under this term are phosphatized limestones, sandstones, shales, and igneous rocks; amorphous nodular phosphates; residual weathered phosphatic limestones; vein phosphates; and phosphate sediments, both unconsolidated and consolidated.

Other phosphatic material, not customarily considered as phosphate rock, occurs in nature and likewise serves as a source of phosphate and a natural substitute for phosphate rock. This material includes phosphate minerals, such as apatite and wavellite, guano, marls, and bones. Unaltered phosphatic limestones are usually too low grade to serve as commercial sources of phosphate. Phosphate rock is valued according to its phosphorus content, expressed as tricalcium phosphate ($Ca_3P_2O_8$) and variously called tribasic phosphate of lime or bone phosphate of lime (B.P.L.). Commercial grades usually contain at least 60 per cent and occasionally as much as 80 per cent B.P.L., though usually ranging between 68 and 77 per cent.

DESCRIPTION

The divers types of phosphate rock are so variable in character that no satisfactory description of them as a whole can be given. They range from soft, unconsolidated sands and gravels to hard, massive, flintlike rocks. In specific gravity they range from 2 to 3 and in color from white to coal black. In some types there is little evidence of organic origin; in others fossil teeth bones, and phosphatic shells occur in abundance. Some types contain noteworthy quantities of bituminous matter.

Mineralogically, the phosphate rocks consist of one or more of the related phosphates of calcium, consisting largely of tricalcium phosphate, intimately intermingled with various proportions of other substances of organic or inorganic origin.

The calcium phosphates present are largely the amorphous types, with smaller amounts of the crystalline varieties. The principal calcium phosphate present in the phosphate rocks is collophane, an amorphous mineral consisting largely of tri-calcium phosphate combined with a small amount of calcium carbonate and an indefinite amount of water. Dahllite, considered the crystalline dehydrated equivalent of collophane, is usually present in smaller quantities. Another related crystalline calcium phosphate reported present in phosphate rocks is francolite.

In addition to calcium phosphates commercial deposits ordinarily contain other substances, notably calcite, magnesite or dolomite, pyrite, limonite, sand clay, and organic matter.

Phosphate rocks, therefore, do not have a definite chemical composition. Not only does the composition of the component calcium phosphates vary within

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certain limits, but other minerals form varying proportions of the whole rock. Chemical analyses show a great predominance of calcium and phosphorus (reported as CaO and P_2O_5); but although most of both elements occur in the several calcium phosphates present some of the calcium may be present in calcite or fluorite, and some of the phosphorus may be in phosphates of elements other than calcium, such as iron or aluminum.

Common impurities are iron and aluminum. The former is ordinarily present as limonite, although pyrite is found in certain types of phosphate rock. Vivianite, an iron phosphate, has been noted at some places but is rare. Aluminum occurs both in the clays and in aluminum phosphates. Silicon occurs both as quartz sand and as silicates in the clays. Magnesium oxide, which is shown in a large number of analyses of phosphate rock, probably occurs most commonly as magnesite or dolomite.

Fluorine is an essential constituent of all the commercial grades and types of phosphate rock produced in the United States. The fluorine ranges between 3 and 4 per cent in amount and occurs chiefly as a constituent of the phosphate minerals of which the rock is composed. Sometimes it is considered as a constituent of the collophane in the rock and sometimes of the francolite. In certain phosphate rocks it is also present as fluorite.

Some phosphate rocks contain traces of iodine, chromium, and vanadium in undetermined combinations.

ORIGIN OF DEPOSITS

The phosphate rock deposits in the United States have widely different origins. The deposits in the Western states, which form the bulk of the domestic reserves, were formerly believed to be phosphatic replacements of calcareous marine oolites but are now considered as bedded marine deposits formed by the direct deposition of calcium phosphate oolites by biochemical and physical agencies from phosphatic solutions or colloids on the sea bottom. The blue phosphate rock of Tennessee is likewise a bedded marine sediment, but its content of calcium phosphate was obtained by the erosion, reworking, and reconcentration of an older phosphate rock formed by the weathering of phosphatic limestones.

Some of the limestones in Tennessee and Kentucky are original marine limestones containing phosphatic shells. The weathering of these limestones with the accompanying leaching out of the calcium carbonate has left the calcium phosphate content as the residual brown phosphate rock of these States.

The white phosphate rock of Tennessee and the hard rock phosphate of Florida are likewise the result of the leaching of phosphatic sediments, but in these instances the calcium phosphate has passed into solution and been carried down and deposited as replacements of other sedimentary rocks or as the filling of open cavities.

The Florida land pebble deposits are apparently sea-beach placer deposits derived from the marine planation of phosphatic limestones and reconcentrated by wave section along the seashore. The river-pebble deposits of that

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State are the result of the river erosion of the land-pebble deposits and subsequent concentration in the bars of the river of the phosphatic materials. The South Carolina river rock is similarly the result of the river erosion of the land rock and its concentration in the river bars. The South Carolina land-rock deposits are reported to be thin beds of phosphatized marine marls.

DEPOSITS IN THE UNITED STATES

General

Phosphate rock deposits of present or recent economic importance occur in the Atlantic Coast States, in Florida, and South Carolina; in the Mississippi Valley region, in Tennessee, Kentucky, and Arkansas; and in the Rocky Mountain region, in Idaho, Montana, and Wyoming. The different deposits differ widely in age, structure, and other characteristics. Their age ranges from Ordovician, as in the weathered phosphatic limestones of Tennessee, to the late Tertiary and Quaternary deposits of Florida. Their structures range from the flat-lying deposits of Florida through the gently domed deposits of Tennessee and Kentucky to the intensely folded and faulted phosphates of the Western States. They range from the unconsolidated sands and gravels of South Carolina and Florida to the hard, heavy bedded rock phosphates of Tennessee, Arkansas, and the Western States.

Florida

The Florida land-pebble deposits occur in west central peninsular Florida extending southward from the Lakeland Hills, which are composed of the Miocene phosphatic limestone bedrock. The boundaries of the land pebble area are not definitely known. The length of the workable area is about 30 miles from northwest to southeast, and the productive belt is 10 to 15 miles wide.

These deposits are flat-lying, unconsolidated sediments of Pleistocene or later age and represent reconcentrations from the marine planated phosphate-bearing Miocene limestone bedrock.

The deposits range in thickness from 5 to 50 feet, the maximum being not more than 50 feet and the average considerably less. The phosphate matrix is overlain by variable thicknesses of overburden comprising barren sand or clay. The matrix itself consists of sand or clay in which are embedded the phosphate pebbles, which range in size from fine sand to pebbles about 1½ inches in diameter. These pebbles form 10 to 50 per cent of the matrix.

The hard rock deposits occur in a narrow belt extending southward from northern Florida through the western half of the peninsula and parallel to its axis for about a hundred miles to a point about halfway down the State. The phosphate-bearing formation has not been accurately mapped, but it ends a considerable distance to the north of the land-pebble area. The width of the belt is variable. The widest known place is in Marion County, where almost the whole of the western half is underlain by the phosphate-bearing formation. The width here is about 30 miles.

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The hard rock phosphate-bearing formation consists of sand, clay, and phosphate rock and is supposedly of Pleistocene age. The thickness of the phosphate-bearing beds is very variable. They attain a maximum thickness of 100 feet in places. The workable deposits of phosphate occur scattered very irregularly throughout the formation, and they vary greatly in size from single masses of less than a ton to irregular deposits containing many thousand tons. The matrix containing the hard rock consists of varying percentages of clay, sand, and soft phosphate. The proportion of hard rock of commercial value rarely exceeds 25 per cent of the deposit. The hard rock phosphate occurs as fragmentary rock, bowlders, plate rock, or pebbles.

The hard rock deposits appear to be the residual product of a phosphatic sandy Miocene limestone, the disseminated phosphate in which was dissolved out and then redeposited as replacements of other beds or in open caverns. Settling of the region by the collapse of the caverns broke up the deposits. All of these actions appear to have taken place in the Pliocene.

South Carolina

The workable phosphate rock deposits in South Carolina are confined to the seaboard zone lying in general between the region of Charleston on the north and Beaufort on the south, and extending about 25 or 30 miles inland from the coast. Those which have been worked occur in a thin horizontal bed which underlies irregular areas within the region defined above. This bed is commonly less than 18 feet below the surface.

Two classes of the phosphate rock have been recognized,- the land rock and the river rock. The land rock occurs in a more or less irregular bed which represents an undisturbed phosphatized Miocene (Tertiary) marl. The river rock consists in part of the original phosphatized marl and in part of fragments derived by erosion from the land rock in Quaternary times and concentrated on the river bottom. The land rock has a maximum thickness of 30 inches, but averages between 8 and 16 inches, and in many places is absent. The river rock occurs in very irregular banks on the river bottoms where the rivers cross the land rock areas. The commercial rock varies greatly in phosphate content, but the general average for the entire region would probably approximate 58 per cent tricalcium phosphate. The highest-grade rock this field can be expected to produce does not average more than 61 per cent, and the combined iron and aluminum oxides generally exceed 3 per cent. The river rock is somewhat lower in phosphate content than the land rock.

The total reserves of phosphate rock in South Carolina have been estimated to be about 9 million tons, consisting chiefly of land rock.

Tennessee

Two distinct types of economically important deposits of phosphate rock occur in Tennessee, known commercially as brown rock and blue rock. The reserves total about 83-1/3 million tons.

The brown rock phosphate is the residual weathered and leached outcrop of the phosphatic Ordovician limestones, exposed over a wide area in the central basin of Tennessee, where erosion in the summit of the Nashville dome has exposed

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around the edges of that dome the underlying gently dipping phosphatic Ordovician limestones. In general, the brown rock is confined to the western edge of the central basin. The eastern edge contains no deposits of the brown phosphate because the limestones of the phosphatic horizon are either absent or, if present, are not phosphatic.

Depending upon the topographic situation of the outcrops, two distinct forms of deposits have been recognized, known respectively as "collar," "hat brim," or "rim" deposits, and "blanket" deposits. The first type of deposit occurs where the horizontal phosphatic limestone outcrops as a narrow band along the face of a steep hill. The blanket deposits occur where erosion has exposed the upper surface - that is, the dip slope of the phosphatic limestones - and sometimes cover wide areas. The brown rock deposits are best developed in the Mount Pleasant district, where the deposits of the blanket type range in thickness from 2 to 10 feet and often greater where the alteration has extended downward along the joints in the phosphatic limestones.

In some places in the brown rock area the deposits are at the surface, but elsewhere they are covered by an overburden consisting of soil and clay and ranging in thickness up to a point where its removal is unprofitable. On the "blanket" type of deposit it is usually less than 20 feet thick.

The so-called blue phosphate rock is a thin, unweathered, highly phosphatic stratum of Devonian or Carboniferous (Mississippian) age, occurring in a rather limited area on the southwestern side of the Nashville dome. It outcrops only in the valley walls of streams which have cut down through the phosphatic formation, which, as in the case of the brown rock deposits, lies almost horizontal. The phosphate bed varies in thickness from a few inches to 3 or 4 feet and in composition from a highly phosphatic oolitic variety to an ordinary shale or sandstone. It is phosphatic only when the underlying Ordovician limestone is phosphatic. The thinner beds contain the higher-grade rock, the thicker beds being generally of inferior quality due to the intermingling of sand with the phosphate. The tricalcium phosphate content of the rock ranges from less than 35 per cent to about 85 per cent. The bed where mined at present is only about 18 inches thick and contains from 65 to about 75 per cent tricalcium phosphate.

Kentucky

The brown phosphate rock deposits of Kentucky, like those of Tennessee, are the weathered outcrops of phosphatic Ordovician limestones, which are exposed in the blue grass region of central Kentucky by the erosion of the broad, low Jessamine dome. These thin-bedded, granular phosphatic limestones are 30 to 40 feet thick and have an average dip of 10 feet to the mile. The brown rock deposits range in thickness from a few inches to 10 or 12 feet, with an overburden up to 10 feet in thickness. Although occasional occurrences of lump phosphate rock containing up to 80 per cent tricalcium phosphate occur and although phosphate rock in workable quantities up to present commercial requirements (70 per cent and over tricalcium phosphate) is found, the bulk of the 900,000 tons of estimated reserves in Kentucky is believed to contain less than 70 per cent of tricalcium phosphate. The content of combined oxides (iron and aluminum) ranges from 6 to 17 per cent in most of the rock and is too high to

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come within normal commercial requirements at present.

Arkansas

Phosphate rock deposits of Ordovician age extend over a considerable area in northern Arkansas. The phosphate beds lie almost horizontally and range in thickness from one-half foot to 6 feet. The bed worked commercially averaged 3½ to 4 feet thick. Analyses of typical samples from the higher-grade phosphate rock of this region are reported to show a content of tricalcium phosphate ranging from 50 to 63 per cent and combined iron and aluminum oxides from 2½ to 9½ per cent. The phosphate rock reserves of this region have been estimated at about 20 million tons.

Western States

Phosphate rock deposits are found in Idaho, Wyoming, Utah, and Montana. Reserves in these States have been estimated to be nearly 6 billion tons, of which nearly 5 billion tons is in Idaho. The phosphate rock occurs at two horizons, one in the upper Mississippian and the other in the Permian. Only the Permian deposits have much commercial value, as those of upper Mississippian age are less extensive and of poorer quality, although their proximity to present lines of transportation would seem to compensate somewhat for this inferiority.

The whole western region has been intensely folded, faulted, and eroded. The phosphate-bearing formations are exposed in narrow bands along the flanks of the larger and simpler folds or in more complex crumplings in the smaller folds or along the borders of faulted areas.

The Permian phosphate-bearing formation is of marine origin and consists of 75 to 180 feet of yellowish to brown phosphatic sandstones, dark brown to black phosphatic shales, beds of brown to black fetid limestone, and one to three economically valuable beds of phosphate rock. The thickest and richest bed of phosphate rock is from 4 to 7 feet thick (and in places even more) over large areas. It is characterized by a gray, brown, or black color, fine to coarse oolitic texture, and a strong fetid odor when broken. In the workable beds the rock contains 70 per cent or more of tri-calcium phosphate and generally less than 2 per cent of iron and aluminum oxides combined.

Selected List of Articles on the Phosphate Rock Deposits of the United States

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C. W. Cooke and Stuart Mossom - Geology of Florida. Florida State Geological Survey, Twentieth Annual Report, 1927-1928, pp. 29-227, Tallahassee, 1929.

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G. S. Rogers - The phosphate deposits of South Carolina. U. S. Geol. Survey Bull. 580, pp. 183-220, 1914.

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W. H. Waggaman - A report on the natural phosphates of Tennessee, Kentucky, and Arkansas. U. S. Dept. Agriculture, Bur. Soils Bull. 81, 1912.

R. W. Smith - Geology and utilization of Tennessee phosphate rock. Trans. Am. Inst. Min. Engr., vol. 74, pp. 127-146, 1926.

J. S. Hook - The brown and blue phosphate deposits of south-central Tennessee. Tenn. Geol. Survey, the Resources of Tennessee, vol. 4, No. 2, pp. 51-83, April, 1914.

W. C. Phalen - The conservation of phosphate rock in Tennessee. Tenn. Geol. Survey, The Resources of Tennessee, vol. 6, No. 4, pp. 193-216, Oct., 1916.

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O. P. Jenkins - Phosphates and dolomites of Johnson County, Tennessee. Tenn. Geol. Survey, The Resources of Tennessee, vol. 6, No. 2, pp. 51-106, 1916.

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A. E. Foerste - The phosphate deposits in the upper Trenton limestones of central Kentucky. Kentucky Geol. Survey, series 4, vol. 1, pt. 1, pp. 391-439, 1913.

A. M. Miller - Geology of the Georgetown quadrangle. Kentucky Geological Survey, series 4, vol. 1, pt. 1, pp. 317-364, 1913.

W. H. Waggaman- A report on the natural phosphates of Tennessee, Kentucky, and Arkansas. U. S. Dept. Agriculture, Bur. Soils, Bull. 81, 1912.

Arkansas

A. H. Purdue - Developed phosphate deposits of northern Arkansas. U. S. Geol. Survey Bull. 315, pp. 463-473, 1907.

W. H. Waggaman- A report on the natural phosphates of Tennessee, Kentucky, and Arkansas. U. S. Dept. Agriculture, Bur. Soils, Bull. 81, 1912.

Idaho

G. R. Mansfield-Geography, geology, and mineral resources of part of southeastern Idaho. U. S. Geol. Survey Prof. Paper 152, 1927. Contains an extensive bibliography on pages 403-409.

V.R.D. Kirkham -Phosphate deposits of Idaho and their relation to the world supply. Trans. Am. Inst. Min. Eng., vol. 71, pp. 308-338, 1925.

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H. S. Gale - Rock phosphate near Melrose, Montana. U. S. Geol. Survey Bull. 470, pp. 440-451, 1911.

J. T. Pardee - Some further discoveries of rock phosphate in Montana. U. S. Geol. Survey Bull. 530, pp. 285-291, 1913.

R. W. Stone and C. A. Bonine - The Elliston phosphate field, Montana. U. S. Geol. Survey Bull. 580, pp. 373-383, 1914.

J. T. Pardee - The Garrison and Philipsburg phosphate fields, Montana. U. S. Geol. Survey Bull. 640, pp. 195-228, 1917.

D. D. Condit, E. H. Finch, and J. T. Pardee - Phosphate rock in the Three Forks - Yellowstone Park region, Montana. U. S. Geol. Survey Bull, 795, pp. 147-209, 1928. Contains an extensive annotated bibliography.

Utah

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A. R. Schultz - A geologic reconnaissance of the Uinta Mountains, northern Utah, with special reference to phosphate. U. S. Geol. Survey Bull. 690, pp. 31-94, 1918.

Wyoming

Eliot Blackwelder - A reconnaissance of the phosphate deposits in western Wyoming. U. S. Geol. Survey Bull. 470, pp. 452-481, 1911.

A. R. Schultz - Geology and geography of a portion of Lincoln County, Wyoming. U. S. Geol. Survey Bull. 543, pp. 131-134, 1914.

G. R. Mansfield - A reconnaissance of phosphate in the Salt River Range, Wyoming. U. S. Geol. Survey Bull. 620, pp. 331-349, 1916.

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PROSPECTING

Florida Land Pebble Field

Both Mansfield and Cash and von Bernewitz have described the methods in use in the Florida land pebble field, and the following summary is based upon their descriptions.

The prospecting operations are carried on with a well drill or hand auger. The auger used is a modified form of post hole auger 4 inches in diameter. A 4½-inch casing is sunk in the hole at the same pace as the auger. The drilling operations are started after an option on the supposed phosphate-bearing area has been secured, but before a lease or a purchase has been made. Preliminary drilling operations are carried through, the holes being put down at widely spaced but regular intervals to determine whether additional drilling is warranted. If this first drilling is satisfactory the minable area is drilled more closely.

Because of the general regularity of the phosphate rock deposits in the land pebble area, comparatively little drilling is necessary, and in commercial practice 16 holes are ordinarily considered enough to test a 40-acre tract. A hole is drilled or bored to bedrock in the center of each 2½-acre square. For each hole a record is kept of the thickness of overburden and of the phosphate rock. While the drill is passing through the phosphate-bearing zone all material taken from the hole is carefully saved, and after the water has been allowed to drain away it is weighed. The sample of phosphate matrix is then hand-washed through a screen-bottom box, the screen having 3/64-inch openings. The undersize from this screen passes to a similar screen having 1-millimeter openings. The undersize from the second box is allowed to go to waste. After all clay and undersize material are scrubbed through the two screens the oversize material on the screens is separately dried over a fire, weighed, and analyzed. The reason for using the two sizes of screens in the sampling is to determine whether the grade of fine material warrants the installation of 3/64-inch or 1-millimeter screens as the finest screens on the washers.

The yardage of overburden is calculated from the logs of the drill holes. From the thickness of the phosphate matrix, the weight of phosphate rock recovered, and the percentage of phosphate rock to matrix the tonnage of phosphate rock in the tract being prospected is computed. Under present conditions, if the calculated amount is less than 3,000 tons per acre, regardless of cover, the deposit is not considered workable. The grade of the available rock is determined from the analyses.

A typical prospecting summary for a phosphate-bearing tract shows the total area, the minable area, the total minable tonnage, and the average per acre, the average depth of the deposit, the average percentage of phosphate rock in the matrix, the average overburden per acre and per ton, and for the washed rock, the average content of tricalcium phosphate, and of iron and aluminum oxides.

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Florida Hard Rock Field

In the Florida hard rock field prospecting is less simple and more expensive than in the land pebble area because of the rough bedrock, the erratic occurrence of the phosphate rock deposits and the presence of large bowlders, all of which combine to render accurate sampling difficult. According to Mansfield the usual practice is to space the holes not more than 50 feet apart and where greater detail is needed only 25 feet apart, or less. The preliminary test holes may be spaced at 100 to 200 foot intervals, and if these prove encouraging intermediate holes are placed as necessary. In this way the shape and size of a commercial body of ore can be carefully outlined.

Drilling methods are different from those in use in the land pebble area. The overburden is usually removed by "cupping." The "cup" used is a vertically slit iron cylinder about 1 foot long and 2 inches in diameter. It is attached to drill rods or pipe of 5-foot or other convenient lengths. When the overburden is too tough or hard for the "cup" and in all cases when the phosphate matrix is reached, the hole is cased with a 2-inch double-thick pipe, and a chisel bit, with ball valve, mounted on a 3/4-inch pipe is introduced. Drilling may be done either by man power with a simple tripod and pulley, or by a power drill.

The thicknesses of the overburden and of the phosphate matrix are determined, together with the amount and quality of the washed and dried phosphate rock. From these data the tonnage and grade of the phosphate rock in the deposit under examination are determined.

Tennessee Brown Rock District

In the brown rock district of Tennessee, according to Barr,

> "The extent, depth and quality of the phosphate deposits are commonly determined by boring with earth augers and post hole diggers 4 inches in diameter. Test pits are also employed in conjunction to give a better idea of the character of the strata.
>
> In blanket deposits the holes are sunk 200 feet apart in squares, while in hat brim formations (ring deposits on a hillside) the holes are spaced 200 feet on the long axis of the deposit and 50 to 200 feet on the short axis, the latter spacing depending upon the width between upper and lower boundaries.
>
> Since the overburden is not excessive, rarely being over 30 feet, the light and cheap 4 inch earth auger gives good results with two operators; 3/4 inch pipe in convenient joints is used for rods. The post hole digger is used for penetrating hard substances like flint or plate phosphate rock. It is merely a form of hollow drill with a 4 by 12 inch barrel of 1/8 inch steel. When penetrating phosphate a sample or disintegrated core is brought up by the tools and must be removed each time when full, necessitating frequent removals of the diggers from the hole.
>
> About every 400 feet a pit is sunk to obtain a sample of rock for recovery tests. This will be representative of the rock as mined by hand

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and sent to the washers, and will also give the true ratio of sand to lump rock with their respective analyses, which is of considerable importance.

The samples from prospecting are prepared for analysis by hand washing in an ordinary wash tub, saving the sand by decantation and separating the lump with the aid of a hose and a 1/8 inch slotted screen. The recovered products are dried, weighed, and analyzed separately. The percentage of recovery is calculated from the weights in the usual manner."

Tennessee Blue Rock Phosphate Deposits

Prospecting methods for phosphate rock in the Tennessee blue rock district differ according to the manner of occurrence of the deposits. When the beds crop out the outcrops are usually exposed by digging shallow pits and then sampled. Where the phosphate bed is under cover the prospecting is done by diamond or shot drills. Records of the thickness of the phosphate bed are kept and analyses made of the outcrop and drill samples.

MINING

General

Depending mainly upon the thickness of the overburden phosphate rock deposits are mined either by open-pit or by underground mining methods.

By far the greater part of the phosphate rock produced in the United States is obtained by open-pit mining in the land pebble and hard rock phosphate fields of Florida and the brown rock phosphate field of Tennessee. The deposits now mined in the United States by underground methods include the nearly horizontal blue rock phosphate deposits of Tennessee and the folded and faulted rock phosphate deposits of the Western States, in which mining methods are quite different.

Mining of Phosphate Rock in Florida

General

All phosphate rock mining in Florida is by open-pit methods. Stripping operations in the hard rock field are by hydraulic methods, while in the land pebble field both hydraulic and drag-line excavating is used. Mining in the hard rock field is by dredges, in the land pebble area by hydraulic methods.

Hard Rock Field

In the stripping operations in the hard rock phosphate field the overburden is broken down with hydraulic giants and washed to a central sump and thence pumped by centrifugal pumps either to pits from which the phosphate rock has previously been removed or to ground under which there is little or no phosphate rock. Water from this stripping is supplied from the dredge pond by electrically driven centrifugal pumps and conveyed through pipes and hose to the hydraulic giants. The overburden is cleaned off for some distance ahead of the regular mining operations.

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The phosphate-bearing matrix is mined by dredges of the long boom dipper type with 1½ cubic yard buckets. Since the excavations are below the permanent ground-water level of the region most of the phosphate is dug below the water level. Wooden trestles carrying single car tracks extend from the washers on the sides of the pit out into the dredge pond. The cars used are of 1-bucket capacity. The dredge is served by a single car at a time. After getting a bucketful of the phosphate matrix the dredge boom is swung until the loaded bucket is over the single car standing near the end of the trestle and the bucket load dumped into the car. The loaded car is then handled by cable operated by friction drum hoists up the inclined railway on the trestle to the top of the washing plant.

Mining Land Pebble Phosphate Rock

In the land pebble phosphate rock field the overburden of sand, sandy clay, or friable sandstone is stripped off either by drag line excavators or by hydraulicking. Throughout this field the phosphate-bearing matrix is mined exclusively by hydraulicking.

The drag line excavators used for stripping at some of the mines are either electric or steam (oil fired). The length of the drag line booms ranges up to 165 feet, with buckets of capacities up to 8 cubic yards. The longest boom in the field at present (1929) carries a 6-cubic yard bucket, while the largest capacity bucket in this area, 8 cubic yards, is serving from a 125-foot boom. The material from the first cut in stripping operations by a drag line is piled alongside the cut or is emptied into a previous cut or abandoned pit.

Both the hydraulic stripping of the overburden and the hydraulic mining of the phosphate rock are carried out in similar manner and with similar equipment. Operations in each case are started with the sinking of a sump at some low point in the area to be hydraulicked. The overburden, or the matrix, as the case may be, is then broken down and sluiced down by hand operated hydraulic giants into the sump hole through small radiating ditches, one from each gun bank. Three guns that branch from a 3-way lateral equipped with three valves are used in each pit. Two of these guns are kept in constant operation. The third gun is held in reserve. The nozzles of the guns are 1½ to 2 inches in diameter. The water for the operation of these giants is furnished by high-speed centrifugal pressure pumps capable of operating against about a 500-foot head, and delivering about 2,000 gallons of water a minute at 200 pounds per square inch.

The pumps used in both overburden and matrix removal are 8 to 12 inch heavy-duty centrifugal pumps, direct-connected to variable-speed motors. The whole unit is mounted on steel frames in a portable housing, which is located in the phosphate rock pit not far from the hydraulicking operations. The suction line is 50 to 150 feet long.

The mixture of water and solids from the overburden sump is pumped to disposal in abandoned pits or stacked on the surface above barren ground. The mixture from the phosphate rock matrix sump, containing 10 to 25 per cent of solids, is pumped to the washing plant, sometimes considerably over half a mile distant, one or more booster pumps being used if necessary.

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The water for the removal of the overburden by hydraulicking and for the hydraulic mining of the phosphate rock is obtained from wells sunk into the underlying limestones or from water-filled abandoned phosphate rock pits. Settling ponds are provided so the water can be used repeatedly.

Mining Phosphate Rock in Tennessee

General

In Tennessee the brown rock is all mined by open-pit methods, and the single operation in the blue rock district is underground.

Mining Tennessee Brown Rock

The clay overburden of the Tennessee brown rock phosphate, ranging in thickness from 1 to 30 feet but usually less than 20 feet, is largely removed by drag-line excavators, with 1½ to 2½ cubic yard scraper buckets on 50 to 85 foot booms. Occasionally narrow benches are stripped by hand, but this is ordinarily expensive. The overburden is removed from a long strip the width of the reach of the drag-line excavator and dumped on previously mined-over ground at one side. The drag-line excavators are also used for mining the deposit wherever possible. Where the phosphate rock is thin or lies in narrow channels ("cutters") in the limestone and can not be mined by drag-line excavators it is mined by pick and shovel. In some of the larger cutters drag lines are used in the mining operations with a man following behind the drag line to clean up the material that the drag-line excavator could not handle. Owing to the depth of some of the cutters the work has to be done in benches of convenient height for the miners. The ore is picked out and shoveled from bench to bench and finally into cars or wagons, in which it is hauled to the mills.

Where hand mining is practiced the phosphate rock is usually screened on the spot where the miner is at work. The fine material passes through the screen and is saved and washed. The coarse rock left is hauled away for drying. In some instances, in small operations mining for lump rock only, the brown rock is loosened with a pick and the lumps are sorted out with a "spall fork".

The phosphate rock mined by the drag-line excavators is dumped into 3-yard end dump or 4-yard side dump cars and hauled to the washers in trains, over 36-inch-gage lines, by 10-ton to 18-ton dinky locomotives.

Mining Tennessee Blue Rock Phosphate

The outcrops of the Tennessee blue rock are exposed only in the valley walls of streams that have cut down through the horizontally bedded phosphate rock. The blue rock was originally mined by stripping and open-cut work along the outcrop. When the overburden became too heavy for this method mining was continued underground by drift mining on the single-entry room-and-pillar system. Main entries are driven from the outcrops into the phosphate rock bed and at regular intervals rooms about 25 feet wide are turned off, leaving pillars of about the same width. Sometimes double rooms 50 feet wide are worked. At

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the only property now in operation there are eight entries of which about five are in use. The longest of the entries is one-half mile in length.

At this mine the phosphate bed averages only 18 inches in thickness, but in places it attains a thickness of 30 inches. It is overlain by a thin shale bed, and the mining practice is to cut out a strip of this shale from the top of the phosphate bed with a Radialax machine before drilling the phosphate rock bed with jackhammers. The bed is loosened and shot up from the floor with dynamite. Compressed air is used for the drills. The broken phosphate rock is loaded by hand into cars and hauled to the plant.

Phosphate Rock Mining in the Western States

In the folded consolidated sedimentary phosphate rocks of the Western States mining operations, as on the blue rock of Tennessee, were at first restricted to surface stripping and opencuts where the overburden was not too thick for that method to be followed. Present methods consist of entering the folded beds at the lowest possible level by short crosscut tunnels, or by adits driven directly in the bed from the outcrop. Drifts are then driven along the strike of the beds. From the drifts stopes are raised toward the surface. The drifts and tunnels serve as haulageways, and, with the stopes, as airways.

At Conda, Idaho, the phosphate bed mined, up to 9 feet thick in places, is exposed in an anticline that plunges northwestward. The dip of the bed ranges from 50° to vertical. It is opened by two southeastward extending crosscut tunnels about one-half mile apart, both of which start on the west limb of the anticline. One tunnel driven southeasterly is substantially on the strike of the east limb of the anticline and reaches the bed at about 2,300 feet from the entrance. The other cuts the west limb of the anticline at about 730 feet from the portal. Drifts follow the phosphate bed, and raises 100 feet apart are run from the tunnel levels to the outcrop 300 to 700 feet above. Intermediate levels are driven from the raises at 100-foot intervals. Stoping operations are carried on from the levels. The tunnels serve as the main haulageways and airways. Animal haulage is used in the development drifts, but main haulage is by electric locomotives. As ore is soft and friable low-strength dynamite is used in blasting.

The phosphate rock bed worked at Montpelier, Idaho, is located on the western flank of a complexly folded and faulted anticline and dips from 17 to 42° west. It is opened by three short crosscut tunnels 50 to 350 feet long driven eastward to intersection with the phosphate bed. Rocks developed by these adits range up to 850 feet. Drifts have been driven along the strike of the bed, raises put up every hundred feet, and the phosphate rock mined by back-stoping.

At Cokeville, Wyo., a 6-foot bed of phosphate rock dipping 75° is being mined by the shrinkage system.

TREATMENT

The treatment accorded phosphate rock after mining depends upon the grade of the mined product. The unconsolidated phosphates of Florida and Tennessee are not marketable as mined and require further treatment to remove sufficient nonphosphatic material to raise the balance to commercial grades, and to

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reduce the content of iron and aluminum oxides to within commercial limits. The blue rock of Tennessee and the phosphate rock of the Western States are of commercial grade as mined and need only to be crushed and dried.

The beneficiation processes for unconsolidated phosphate rock in the plants using wet treatment, as all do except one plant in Tennessee, include sizing, disintegration and washing, screening, classification, and drying.

The coarse sizing is done usually by grizzlies and trommels. In the Florida hard rock field both are used, the grizzlies with 8 or 10 inch spacing, taking out oversize flint, limestone, and phosphate rock bowlders. The latter are broken by hand-sledging or bulldozing to pass the grizzlies, all of the undersize then passing to trommels with 4-inch holes, the oversize from which is crushed to 2 inches before passing to log washers. In the Florida land pebble field, with finer material to handle, the limiting screens are trommels with 1 1/2-inch holes, which remove the clay balls, limestone bowlders, and debris. In some plants these trommels are the first in line and in others follow a fine stationary retaining screen with 3/64 inch or 1-millimeter holes. In the Tennessee brown rock field this preliminary sizing is done principally with grizzlies, although in one plant a slotted screen is used. Two plants put everything through a crusher first, one of them then taking out the lump rock with a trommel with 3-inch holes. The other plant crushes everything to less than 3 inches and then passes the material on for disintegration.

Disintegration of the matrix is accomplished in a variety of machines, the preference being for log washers and trommels. In the hard rock region of Florida log washers only are used for this purpose. In the land pebble area log washers and trommels are favored, although ball mills and scrubbers are included in some plants. A greater variety of types is seen in the Tennessee brown rock field, log washers, rotary cylinders, trommels, emulsifiers, and ball mills being used for separating the clay and phosphate sands and rock.

Separation of the phosphatic material from the disintegrated pulp is carried on coincidentally with the disintegration and subsequently, and is done with a wide variety of screens, tables, and mechanical and hydraulic classifiers. The simplest practice is that followed in the Florida hard rock field, where the phosphate rock after treatment in log washers, where much of the clay and fine material is removed, passes into a double-jacketed trommel which removes the remaining fine material less than 1/16 inch in diameter, keeps the fine hard rock saved from going on the picking table, and passes the oversize from the coarse inner screen to the revolving waste-picking table.

In the land pebble field the pulp remaining from the preliminary sizing operations is screened after each disintegration treatment, the undersize pulp passing to debris ponds or to reclaimer units, and the pebble discharge passing on to the units making the final separations. In the nrothern part of the field this is done with double-jacketed trommels, whereas at the extreme southern end of the field vibrating screens have been adopted. Plants at intermediate points use vibrating screens after double-jacketed trommels, taking final products from each.

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In the Tennessee brown rock field, after all the clay and sand are in suspension, the coarser phosphatic material is removed by screening and the finer phosphatic material from this and preceding operations is separated from the clay in mechanical or hydraulic classifiers. These include jet cones, inverted pyramids, cylindrical jet tanks, hydraulic cones, dewatering cones, drag classifiers, bowl thickeners, bowl classifiers, and tables. As the principal impurity associated with the brown phosphate rock is clay the separation can be carried to finer material than in the Florida land pebble field where the quartz grains associated with the phosphate sands introduce a more complicated problem of separation.

The fine pulp from the various washing and classifying treatments is allowed to go to waste in the Florida hard rock field and in some of the plants in the land pebble area. In many of the land pebble washers, however, the fine discharges from the various treatments are passed through reclaimer units using various combinations of settling boxes, log washers, trommels, screens, or sand cones. In the Tennessee brown rock field the fine pulp from the various washing and classifying apparatus passes to fine sand recovery units, using thickeners, settling boxes, bowl classifiers, or cones.

The wet phosphate rock from the washers is dumped at the drying plants in outdoor wet storage piles or in wet rock bins, for draining, which reduces the moisture content several per cent.

Drying of the wet rock is done in direct-heat rotary driers, reducing the moisture content from 12 to 18 per cent down to ½ to 3 per cent. In the Florida fields countercurrent oil-fired driers 30 feet long and 3½ or 4 feet in diameter are used. In Tennessee both parallel and countercurrent types are in use, and the driers are longer, 30 to 50 feet in length, and of greater diameter, 5 to 7 feet.

Figures 1, 2, and 3, typical flow sheets of washers in the Florida hard rock and land pebble fields and the Tennessee brown rock field follow. Figure 3 is based on a flow sheet in R. W. Smith's article, Mining and Washing Phosphate Rock in Tennessee, in the Engineering and Mining Journal, volume 115, 1923, pages 221 to 226.

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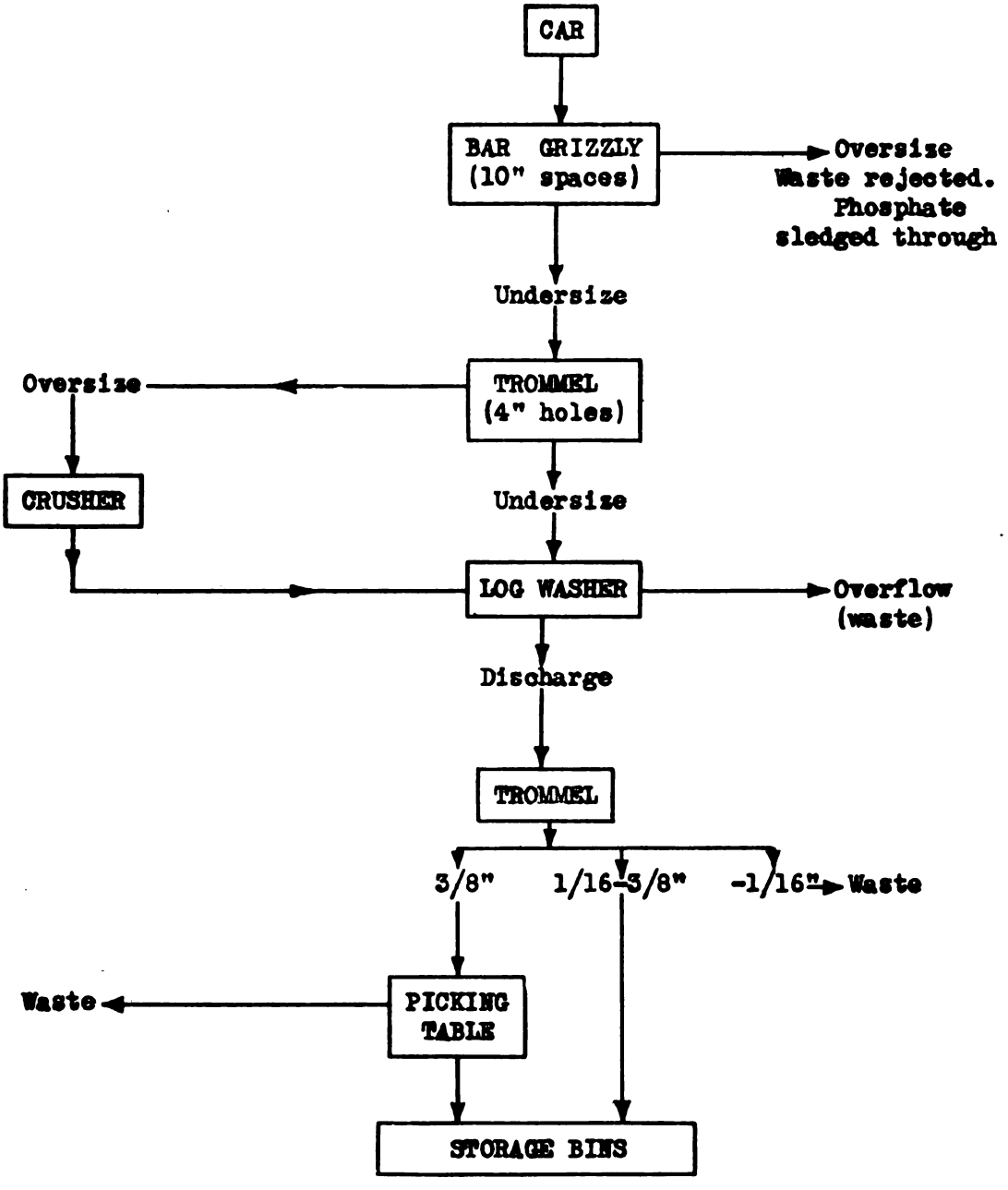

Figure 1.- Typical flow sheet of Florida hard-rock washer

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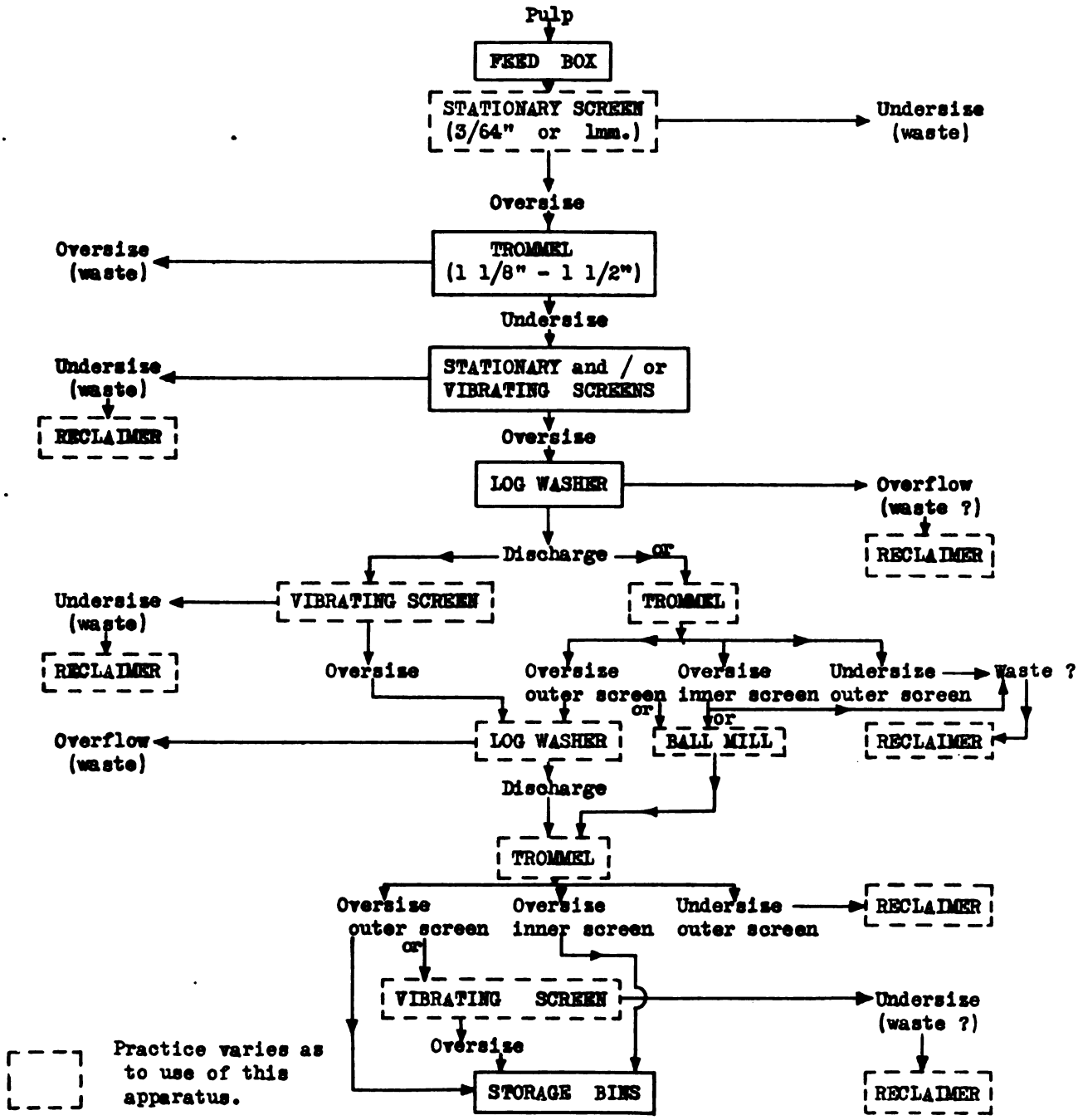

Figure 2.- Generalized flow sheet of Florida land-pebble washers

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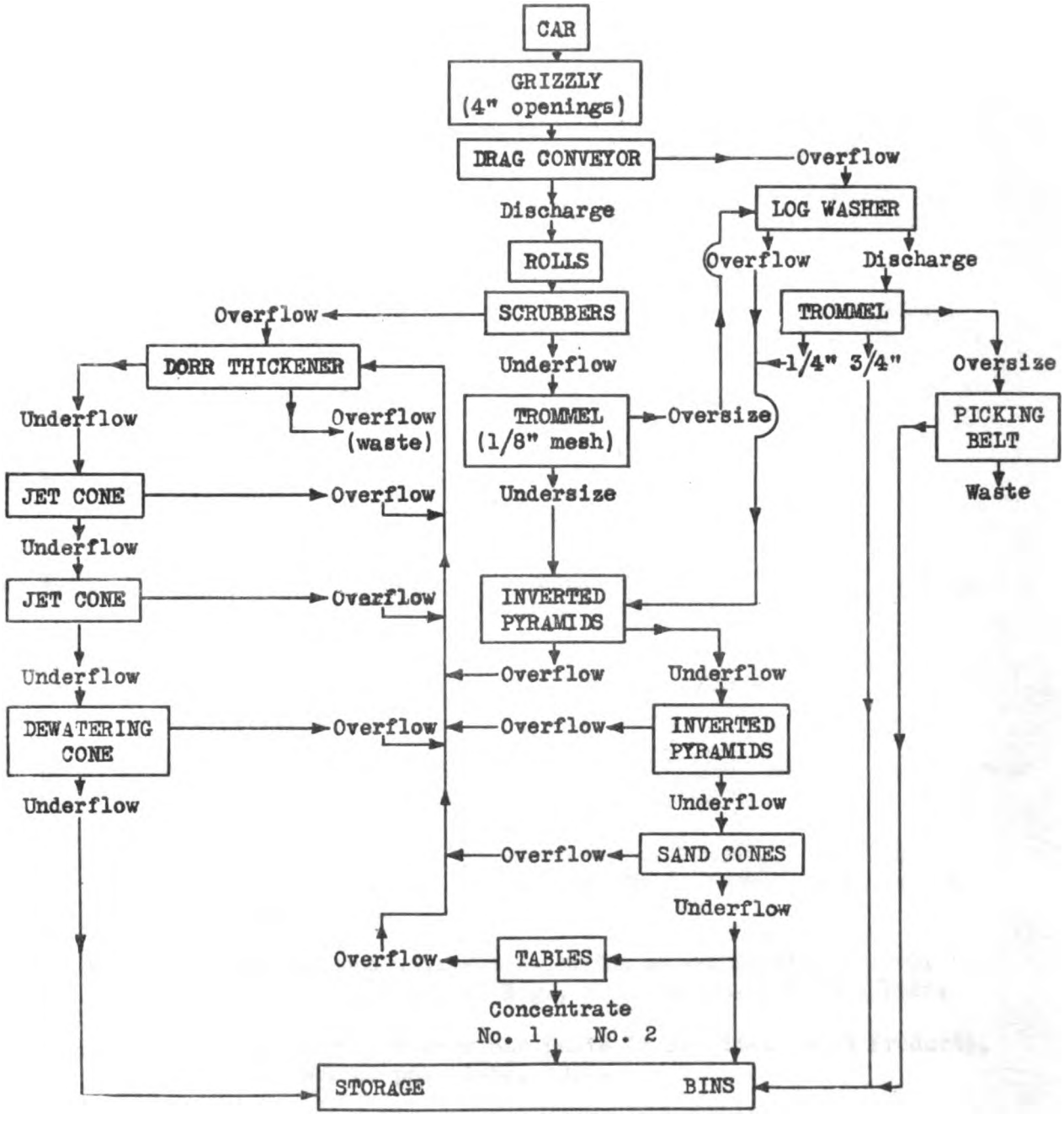

Figure 3. Typical flow sheet of Tennessee phosphate washer

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USES

The uses for phosphate rock are comparatively limited. They can be classified in two distinct groups, one in which the phosphate rock undergoes some chemical change during processing, and the other in which the rock is not changed chemically in treatment.

The first group accounts for about 98 per cent of the annual domestic consumption of phosphate rock and includes the use of phosphate rock in the preparation of phosphorus, phosphoric acid, superphosphate, triple (or treble) superphosphate, dicalcium phosphate, and ferrophosphorus and in the manufacture of pig iron. The other group comprises the uses of phosphate rock for direct application to the soil, as road metal, concrete aggregate, poultry and stock feed, and filler for various purposes.

The principal use of phosphate rock, and one that takes about 90 per cent of the annual domestic consumption, is in the preparation of the phosphatic fertilizers - superphosphate, triple (or treble) superphosphate, and diacalcium phosphate - which are prepared by the use of acidulation processes (with sulphuric, phosphoric, and hydrochloric acids, respectively). An additional 1½ per cent of the domestic consumption consists of the dried and finely ground phosphate rock used for direct application to the soil. Of the minor uses, by far the most important use is in the manufacture of phosphorus and phosphoric acid, which in turn are used for the preparation of numerous phosphorus-containing compounds employed in various arts and industries. The uses of phosphorus in the iron and steel industry consume but a few thousand tons of phosphate rock annually. Ferrophosphorus, produced by the smelting of phosphate rock and iron ore or scrap iron, is employed almost exclusively as an addition to certain kinds of steel. For adjusting the phosphorus content of pig iron phosphate rock is included in proportion in the blast-furniace charge.

Elemental phosphorus is used to a limited extent in the match heads of the ordinary "strike anywhere" matches in certain countries; on the striking surface on boxes of safety matches; to a limited extent in medicine; in vermin-destroying pastes; in range shells, tracer bullets, grenades, smoke screens, and incendiary shells; in fireworks; and in the manufacture of sundry phosphorus compounds. Among the compounds may be mentioned ordinary phosphoric acid; hypophosphorus acid and hypophosphoric acid, which are both used in the manufacture of salts for medicinal purposes; phosphorus sesquisulphide (which has largely replaced elemental phosphorus in match making); calcium phosphide (one of the constituents of distress signals at sea); copper phosphide and tin phosphide (used in the manufacture of phosphor copper, phosphor tin, and phosphor bronzes); and zinc phosphide (for medicinal use).

The only phosphoric acid of commercial importance is the orthophosphoric acid, available on the market in various densities and purities. It has considerable number of uses, among which are its use in sugar refining, rust-proofing of iron and steel, soft drinks, water softening, dental and china cements, photography, medicine, jams, and jellies, and in the manufacture of triple superphosphate, various phosphate salts, and hydrogen peroxide. Salts of phosphoric acid have a wide application in the arts and industries. Phos-

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phates of calcium and of sodium are the most used. Other phosphates, such as phosphates of potassium, aluminum, ammonium, magnesium, barium, manganese, and cobalt, are produced, but their use is limited.

Of the calcium phosphates monocalcium phosphate is used most widely. It finds its largest use in the manufacture of baking powders and self-rising flours. It is also used in sugar refining and yeast culture. Dicalcium phosphate is used in the manufacture of monocalcium phosphate and baking powder and in yeast culture. Tricalcium phosphate, in relatively small quantities, has been used in medicinal preparations. A wider use is its employment as a conditioner of table salt.

Trisodium phosphate is the most important of the sodium phosphates. Its widest use is for general household and industrial cleaning. Minor uses are for water softening, in the manufacture of tricalcium phosphate, and in the preparation of paint removers. Disodium phosphate is chiefly used for weighting silk. It is also used in water-softening, medicines, manufacture of loaf cheese, fireproofing mixtures, optical glass, ceramic enamels, and photography, in vinegar manufacture (as a food for vinegar bacteria), and in analytical work in chemical laboratories. Monosodium phosphate is relatively unimportant commercially. Limited quantities are used in baking powder and in medicines and to an even smaller extent as a leavening agent, in electroplating, in fireproofing mixtures, and in photography. It is also produced as an intermediate product in the manufacture of sodium acid pyrophosphate.

Monoammonium phosphate is used in yeast culture, fireproofing, food products, and impregnating match stems to prevent afterglow. Sodium ammonium phosphate is also used in fireproofing mixtures. Monopotassium phosphate is used in baking powders, yeast culture, and photography. Both dipotassium and tripotassium phosphate are used in photography. Aluminum phosphate is used in silicate dental cements. Barium, sodium, and calcium phosphates are used in glass making. Many metallic phosphates are used in coloring for hard porcelain and clays. Minor quantities of phosphates of silver, uranium, manganese, barium, and vanadium have been used in photography.

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WORLD PRODUCTION

The world production of phosphate rock for the period since 1913 has varied from about 3¾ millions to over 10 million tons. The normal growth of the phosphate rock producing industry during this period was tremendously altered by the World War. In the prewar year 1913, the world production amounted to slightly over 7 million tons, 76 per cent of which came from the United States and the French colony of Tunisia. In 1915, because of the war, the world production fell to about 3,800,000 tons. From 1915 to 1919 it rose gradually to a little over 4¼ million tons in 1919. This small rise was due largely to the increased production of the United States, which started in 1916. The decline in Tunisia production, which had begun with the opening of the war, continued until 1917; then recovery set in, and its increased production helped raise the world total and offset a slight falling off in the production of the United States in 1918 and again in 1919. In 1920 the world production made a spectacular rise almost to 7 million tons. This sudden recovery to prewar levels was due almost entirely to the tremendous boom in the phosphate rock mining industry in the United States, where production, increasing nearly 2 million tons over the preceding year, reached a new high mark that has not yet been surpassed. The business depression of 1921 in the United States reduced American phosphate rock production down nearly to war-time levels, and in consequence the world production fell to a little over 5¼ million tons. Except for a slight decline in the production of Algeria there was practically no falling off in that year in other countries.

Since 1921 the world production of phosphate rock has risen rapidly and in 1927 was nearly 10½ million tons, an increase of 43 per cent over the 1913 production. The production in 1928 was apparently slightly less than that of 1927, probably about 10 million tons.

During the period from 1913 to 1928 there has been no change in the relative rank of the two leading producing countries. The United States has

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led throughout this period, with the French North African colony of Tunisia in second place. Algeria held third place until 1927, when it became fourth in the list, yielding third place to French Morocco, which had increased rapidly its production after its advent as a producer in 1921.

At present three national groups produce all but a few per cent of the world production of phosphate rock. Of the 10 million tons produced in 1928, France and French possessions, the United States, and the British Empire produced about 94 per cent. France with her colonies now leads all other nations in phosphate rock production, producing 51 per cent of the total in 1928. The United States produced 38 per cent and the British Empire 8 per cent. No other nation produced over 2 per cent of the world total.

The production in the various countries for 1913 to 1928, both years inclusive, is given in the following table:

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World Production of Phosphate Rock, by Countries, Calendar Years, 1913-1928, in metric tons[1]

Country	1913	1914	1915	1916	1917	1918	1919
Algeria	377,934	2/ 355,140	2/ 225,891	2/ 389,211	2/ 234,825	198,539	271,162
Angaur Island	90,000	2/ 60,000	30,000	30,000	3/	3/	30,500
Australia:							
Queensland	-	-	-	-	-	-	-
New South Wales	2,032	-	-	-	2,032	305	585
South Australia	6,045	6,197	4,688	5,093	5,183	8,204	6,045
Victoria	-	-	-	-	1,549	3,438	2,521
Belgium	219,420	105,330	16,350	77,740	138,300	61,700	90,970
Canada	4/ 349	4/ 866	4/ 197	4/ 184	4/ 135	4/ 127	4/ 22
Chile	-	-	-	-	-	-	4/ 1,500
Christmas Island (Straits Settlements)	152,405	95,234	24,119	44,209	91,332	54,227	69,722
Egypt	104,450	71,945	82,998	125,008	115,732	31,147	29,365
Estonia	-	-	-	-	-	-	-
France	293,859	270,000	145,000	24,700	3/	3/	103,869
Germany:							
Bavaria	-	-	-	-	-	-	4/ 701
Prussia	-	-	-	-	-	4/ 1,822	4/ 1,283
Gilbert and Ellice Islands	-	-	-	-	-	-	-
Guiana, French	3,193	-	-	-	3/	-	-
India, British	-	-	-	-	-	4/ 5,182	4/ 508
Indo-China	-	-	-	-	3/	3/	7,050
Japan 5/	25,013	38,264	57,723	114,389	121,628	192,271	122,868
Taiwan	-	-	-	-	-	-	5
Madagascar	-	-	-	-	-	-	-
Makatea Island	82,056	72,925	71,724	39,285	32,250	40,000	40,000
Morocco, French	-	-	-	-	3/	3/	3/
Nauru and Ocean Islands	250,000	-	-	70,000	202,000	155,000	115,000
Netherlands W. Indies							
Aruba	38,150	86,572	51,000	14,700	-	-	-
Curaçao	1,850	11,219	32,915	-	3,639	-	2/ 10,058
New Caledonia	2,100	3,500	8,400	-	6,004	7,925	5,729
New Zealand	11,176	-	-	-	5,131	5,080	4,064
Norway	4/ 757	4/ 750	4/ 1,901	4/ 2,236	4/ 1,832	4/ 4,562	4/ 1,168
Philippine Islands	-	-	-	-	-	-	300
Portugal	-	-	-	-	-	-	-
Russia	25,000	15,000	-	-	3/	3/	3/
Seychelles Islands	-	-	-	-	-	-	-
Spain	3,548	8,312	9,080	14,111	28,148	43,303	25,035
Tunisia	2,284,678	1,395,630	1,170,033	1,041,204	576,000	862,494	1,075,214
United States	3,161,147	2,777,916	1,865,124	2,014,196	2,625,757	2,530,729	2,308,442

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World Production of Phosphate Rock, By Countries, Calendar Years, 1913-1926, in metric tons (Cont'd.)

Country	1920	1921	1922	1923	1924	1925	1926
Algeria	502,614	398,800	484,304	467,384	631,136	815,116	929,355
Angaur Island	6/ 30,500	6/ 30,500	46,204	61,243	1/ 61,000	1/ 61,000	1/ 61,000
Australia:							
Queensland	-	375	66	-	-	-	-
New South Wales	156	203	12	75	109	203	257
S.Australia	8,393	5,161	2,759	453	85	754	896
Victoria	4,290	1,566	1,114	488	541	-	122
Belgium	133,040	55,040	56,840	23,270	26,250	15,125	30,030
Canada	-	4/ 27	4/ 172	4/ 27	-	4/ 15	4/ 36
Chile	4/ 1,510	4/ 1,200	4/ 500	-	-	-	-
Christmas Island(Straits Settlements)	2/ 70,692	2/ 87,893	2/ 100,947	2/ 71,563	2/ 127,166	2/ 111,835	2/ 131,057
Egypt	114,813	122,024	60,220	25,370	87,869	106,778	232,008
Estonia	-	-	3/ -	304	-	2,044	4,054
France	124,929	111,984	146,526	179,462	206,859	230,496	252,163
Germany:							
Bavaria	4/ 4,934	4/ 7,959	4/ 4,412	4/ 2,975	4/ 1,000	4/ 200	-
Prussia	4/ 1,927	4/ 925	4/ 657	4/ 2,311	4/ 399	4/ 123	4/ 542
Gilbert and Ellice Islands	-	3/ -	8/ 152,368	8/ 136,506	8/ 192,516	3/	3/
Guiana, French	-	-	-	-	-	-	-
India, British	-	4/ 353	1,362	4,838	6,529	1,504	730
Indo-China	13,200	9,900	7,600	9,847	12,461	30,236	14,511
Japan 5/	97,340	32,001	12,320	33,107	85,617	87,375	108,569
Taiwan	-	18	-	-	-	449	6,135
Madagascar	-	-	2/ 5,210	-	2/ 749		
Makatea Island	32,000	60,000	2/ 71,350	2/ 74,230	2/ 89,611	2/ 81,061	2/ 127,177
Morocco, French	3/	33,000	96,397	225,395	461,582	692,181	882,821
Mauru and Ocean Islands	9/ 392,000	10/ 370,000	10/ 367,000	8/ 318,794	8/ 459,162	8/ 478,278	8/ 398,059
Netherlands W. Indies:							
Aruba	-	-	-	-	-	-	-
Curaçao	2/ 61,440	2/ 60,872	2/ 50,078	2/ 85,855	2/ 100,471	2/ 81,771	2/ 106,807
New Caledonia	11,421	5,000	5,142	12,932	2/ 8,169	12,000	10,647
New Zealand	5,427	6,108	3,178	2,421	1,600	-	-
Norway	-	4/ 1,068	-	4/ 222	4/ 345	4/ 467	4/ 343
Philippine Islands	-	-	2,050	3,781	6,523	7,523	7,512
Portugal	1,775	1,054	-	-	-	-	-
Russia	3/	3/	14,136	11/ 30,492	11/ 28,380	11/ 39,824	11/ 72,516
Seychelles Islands	-	-	-	-	-	2/ 3,259	2/ 3,259
Spain	42,896	38,064	6,492	5,397	6,746	5,315	5,656
Tunisia	1,075,180	1,800,000	2,117,650	2,338,000	2,391,000	2,691,000	2,568,000
United States	4,169,839	2,097,146	2,456,683	3,054,955	2,913,809	3,537,692	3,261,487

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WORLD PRODUCTION OF PHOSPHATE ROCK, BY COUNTRIES, CALENDAR YEARS 191?-192?, in metric tons,[1](Cont'd).

Country	1927	1928
Algeria	319,10?	3/
Angaur Island	7/ 61,000	7/ 61,000
Australia:		
Queensland	-	-
New South Wales	1?2	3/
South Australia	761	3/
Victoria	-	3/
Belgium	3/ -	3/
Canada	1?7	396
Christmas Island (Straits Settlements)	2/ 11?,55?	3/
Egypt	279,?39	3/
Estonia	?,576	3/
France	3/ -	3/
Germany:		
Bavaria	-	3/
Prussia	44?	3/
Gilbert and Ellice Island	3/	3/
Guiana, French	-	-
India, British	61?	3/
Indo-China	20,?00	3/
Japan 5/	75,3?6	3/
Taiwan	-	-
Madagascar	6,4?0	3/
Makatea Island	2/ 1?5,666	3/
Morocco, French	13/1,19?,000	12/1,?37,079
Nauru and Ocean Islands	3/ 533,345	3/ 509,970
Netherlands W. Indies:		
Aruba	-	-
Curacao	2/ 10?,??1	3/
New Caledonia	9,000	3/
New Zealand	-	3/
Norway	-	3/
Philippine Islands	705	3/
Russia	11/ 56,460	3/
Seychelles Islands	2/ 11,511	3/
Spain	4,202	3/
Tunisia	?,075,000	2,?59,000
United States	?,221,579	?,495,122

1/ Mineral Resources of the United States, Part II.
2/ Exports.
3/ Data not available.
4/ Apatite.
5/ Japan, including Rasa Island, 191?-1917, inclusive
6/ Estimated annual production.
7/ Approximate production (Imperial Institute, London).
8/ Exports during the fiscal year ended June 30, of the year stated.
9/ Eighteen months- July, 1919 to Dec., 1920.
10/ Production in the fiscal year ended June 30, of year stated.
11/ Year ended Sept. 30th.
12/ Shipments, of which, 1,323,293 tons represent exports.
13/ Shipments.

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The world's annual consumption of phosphate rock is now around 10 million tons. More than half of this--about 6 million tons is consumed in the group of countries, chiefly France, United Kingdom, Italy, Germany, and Spain, forming western Europe, making this region the premier world market for phosphate rock. The United States ranks next to Europe in importance as a market for phosphate rock, although despite its greater area it consumes less than half as much. It is, however, the leading single consuming nation of the world; in 1928 its consumption amounted to about 2,600,000 tons, almost all of which was domestically produced.

France, the second largest consuming country, and by far the largest consuming country in Europe, requires about one and three-quarter million tons annually to meet her needs. Of this she produces only about a quarter of a million tons, importing the balance from her North African colonies of Tunisia, Morocco, and Algeria.

The British Empire as a unit ranks third among the nations of the world as a consumer of phosphate rock, taking nearly a million and a quarter tons a year, divided principally between Australia and New Zealand, which together take nearly 800,000 tons annually, and the British Isles which require about 400,000 tons a year. Australian needs are met largely by phosphate rock from the near-by islands of Nauru, Ocean, Christmas, Gilbert, and Ellice; those of the British Isles by importations principally from the French North African colonies.

The phosphate rock requirements of Italy, around 900,000 tons annually, are met almost entirely by imports, mostly from French North Africa.

Germany consumes about 800,000 tons of phosphate rock a year. Its own production being negligible, it imports almost its entire requirements, principally from the United States, French North Africa, and Belgium.

Spanish requirements of phosphate rock are in the neighborhood of half a million tons annually and are satisfied largely by importations from the United States and French possessions.

The only important Asiatic consumer of phosphate rock is Japan, with an annual consumption probably between 700,000 and 800,000 tons, of which about 470,000 tons are imported, chiefly from the United States and British possessions.

DOMESTIC PRODUCTION

Production of phosphate rock started in the United States in 1867, following its discovery in South Carolina, and for many years South Carolina was the only producing State. Florida began production in 1888 and Tennessee in 1894. The higher grade of the phosphate rock from these States caused a decline in the South Carolina production, but the United States total continued to rise, the increased production of Florida and Tennessee more than counterbalancing the decreasing production from South Carolina. Since 1899 Tennessee production has become more or less stabilized at between 400,000 and 500,000 tons a year. The production in Florida, however, has continued to increase, this increase alone now more than making up for the decline of the phosphate rock production in South Carolina. The United States production continued to

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expand up to the outbreak of the World War.

During the World War period and the succeeding years the production of phosphate rock in the United States and in the two leading producing States of Florida and Tennessee fluctuated considerably and in different degrees, although synchronously, the larger fluctuations occurring in the Florida production. In all cases there was a decline during the early war years, a recovery in the late war period, a post-war boom in 1920, when the United States production reached its maximum of 4,103,902 long tons, a slump in 1921, and a gradual recovery since.

Florida is the leading phosphate rock producing State, a position it has held continuously since 1894, when it took the lead from South Carolina. Its production increased steadily from the opening of the industry in that State until the outbreak of the World War. In 1913 the production of Florida had reached 2½ million tons, but following the outbreak of hostilities in Europe it declined to less than 1½ million tons in 1915. Recovery from this low point has been complicated by the labor difficulties of 1919, the boom of 1920, and the general business depression of 1921; nevertheless, although wide fluctuations have occurred in the production in these years, the general trend has been upward. The maximum annual production of the State, 3,369,384 long tons, was reached, however, in the 1920 boom.

The land-pebble field furnishes 97 per cent of the Florida production. The production of this field reached its prewar peak of 2,055,482 long tons in 1913. In the early years of the World War production of land pebble phosphate declined to 1,308,481 long tons in 1915, since which time there has been a general upward trend, marked, however, with wide fluctuations due to the causes above cited. The boom of 1920 resulted in a production of 2,955,182 long tons, the highest ever recorded. The general depression of 1921 brought the production down to the war levels, but it has since recovered to 93 per cent of the 1920 high.

In 1928 eight companies reported production of land-pebble phosphate rock, as follows:

Amalgamated Phosphate Co., 535 Fifth Ave., New York, N.Y.
Mines at Brewster and Green Bay.
American Agricultural Chemical Co., 420 Lexington Ave.,
New York, N. Y. Mine at Pierce.
Coronet Phosphate Co., 99 John St., New York, N. Y.
Mines at Pembroke and Plant City.
Florida Phosphate Mining Corporation, Norfolk, Va.
Mine near Bartow.
International Agricultural Corporation, 61 Broadway,
New York, N. Y. Mines at Mulberry.
The Phosphate Mining Co., 110 William St., New York, N.Y.
Mines at Bartow, Nichols, and Christina.
Southern Phosphate Corporation, 1100 Garrett Bldg.,
Baltimore, Md. Mines at Eaton Park
and Lakeland.
Swift & Co., Union Stock Yards, Chicago, Ill. Mine near Bartow.

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The production from the Florida hard rock fields constitutes but 3 per cent of the State's production; and its general trend has been downward, as indicated by a decline from its maximum of 646,156 long tons in 1907 to 92,627 long tons in 1928. The World War caused a great curtailment, the production dropping to less than 18,000 tons in 1917, but the post-war boom brought it up to about 400,000 tons. Another large decline to 175,000 tons - occurred in 1921, and subsequently the output has dwindled to even smaller proportions.

The producing companies in 1928 were:

1. Mutual Mining Co., Savannah, Ga. Mines near Inverness and Dunnellon.
2. J. Buttgenbach&Co., Dunnellon. Mines at Dunnellon and Hernando.
3. C. & J. Camp, Ocala. Mine at Dunnellon.

Tennessee is the second largest phosphate rock producing state, ranking next to Florida, and has maintained this position since it passed South Carolina in 1899. After the opening of the Tennessee fields in 1894 the movement of phosphate rock from Tennessee mines climbed rapidly until 1899, then more slowly to 1907, when it reached a maximum of 638,612 long tons. The growth of the industry was curtailed by the 1908 depression, and production fell to 341,115 tons in 1909. Slow recovery followed to a second peak of 621,396 tons in 1920. The 1921 depression was a more serious blow to Tennessee industry than the 1908 depression, for the marketed production fell in that year to 264,159 tons, the lowest since 1897. Production in 1928 was only 90 per cent of the maximum annual production yet recorded, that of 1907.

Of the two types of phosphate rock produced in Tennessee - brown rock and blue rock - about 90 per cent of the production comes from the brown rock fields. Production of blue rock has always been small. Data available indicates a maximum annual production of about 80,000 tons in 1908.

There were 14 phosphate rock-mining companies operating in Tennessee in 1928. These companies are:

The American Agricultural Chemical Co., 420 Lexington Ave., New York, N. Y. Mine at Spring Hill.
Armour Fertilizer Works, III West Jackson Boulevard, Chicago, Ill. Mines near Columbia.
Charleston, (S. C.) Mining & Manufacturing Co.. and
Charleston Mining Co., 11 South Twelfth St., Richmond, Va. Mines at Gordonsburg and Mountpleasant.
J. K. Davis, Mountpleasant. Mine at Mountpleasant

Federal Chemical Co., 1100 Lincoln Building, Louisville, Ky. Mines at Southport, Century and Ridley.
Harsh Phosphate Co., R.F.D. 7, East Station, Nashville Mine nr Nashville
Hoover & Mason Phosphate Co., 2300 Willoughby Tower, Chicago, Ill. Mine at Mountpleasant.

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International Agricultural Corporation, 61 Broadway, New York, N. Y. Mines at Mountpleasant and Vales.
J. J. Jones, Mountpleasant. Mine at Mountpleasant.
S. T. Jones, Mountpleasant. " " "
W. A. Kittrell & Co., Mountpleasant.
Ligon & Huff, successors in 192[illegible] to Huff & Ligon, Mountpleasant. Mine at Southport.
New England Phosphate Corporation, Centerville. Mine at Centerville.
Tennessee-Illinois Phosphate Co., 137 South La Salle Street, Chicago, Ill. Mine at Tromey.

The Western States usually furnish between 1 and 2 per cent of the total marketed production of phosphate rock in the United States. Two distinct periods of growth occurred in the production of the Western States. The early period from 1905 to 1916 is characterized by growth to an annual production of nearly 12,000 tons followed by a gradual decline to but 1,703 tons. The later period from 1917 to date is one of rapid growth with wide fluctuations in annual production with a maximum of 72,631 long tons in 1925.

Three phosphate rock producing companies were operating in the Western States in 1927, two in Idaho, and one in Wyoming. They were as follows:

Anaconda Copper Mining Co. (Fertilizer Department), Conda, Caribou County, Idaho.
San Francisco Chemical Co., 112 Market Street, San Francisco, Calif. Mine at Montpelier, Bear Lake County, Idaho.
Cokeville Phosphate Co., Cokeville, Lincoln County, Wyoming.

From 1867 to 1888, South Carolina was the only producing State, but its maximum production of 541,645 long tons was reached in 1889. Following the entrance into the market of the higher-grade phosphate rock from Florida, in 1888, and Tennessee in 1894, the production of South Carolina began a gradual steady decline that eventuated in the final disappearance of that State from the ranks of producers in 1925.

Production in other States has been small and spasmodic, and the industry short-lived. Production has been recorded in Kentucky, Arkansas, North Carolina, Alabama, and Pennsylvania. Kentucky, the leader of this group both in length of life of the phosphate industry and in quantity produced, reported production for but 12 years, with a maximum annual production of only 14,282 long tons.

The following table shows the marketed production of phosphate rock in the United States from 1900 to 1928, both years inclusive.

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Production of Phosphate Rock, by States, Calendar Years, 1900-1928.

Calendar years	U. S. total		South Carolina		Florida		Tennessee		North Carolina	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1900	1,491,216	$5,359,248	329,173	$1,041,970	706,243	$2,983,312	454,491	$1,328,707	--	--
1901	1,483,723	5,316,403	321,181	961,840	751,996	3,159,473	409,653	1,192,090	--	--
1902	1,490,314	4,693,444	313,365	919,725	785,430	2,564,197	390,799	1,206,647	--	--
1903	1,581,576	5,319,294	258,540	783,803	860,336	2,986,824	460,530	1,543,567	45	$500
1904	1,874,428	6,580,875	270,806	861,317	1,072,951	3,974,304	530,571	1,745,054	--	--
1905	1,947,190	6,763,403	270,225	878,169	1,194,106	4,251,845	482,859	1,633,389	--	--
1906	2,080,957	8,579,437	223,675	817,068	1,304,505	5,585,578	547,677	2,147,991	--	--
1907	2,265,343	10,653,558	257,221	980,867	1,357,365	6,577,757	638,612	3,047,836	--	--
1908	2,386,138	11,399,124	225,495	989,881	1,692,102	8,484,539	455,431	1,877,221	--	--
1909	2,338,264	10,796,456	207,954	910,586	1,779,702	8,541,301	341,115	1,310,529	--	--
1910	2,654,988	10,917,000	179,659	733,057	2,067,507	8,647,774	392,588	1,480,950	--	--
1911	3,053,279	11,900,693	169,156	673,156	2,436,248	9,473,638	431,566	1,688,267	--	--
1912	2,973,332	11,675,774	131,490	524,760	2,406,899	9,461,297	420,206	1,626,476	--	--
1913	3,111,221	11,796,231	109,333	440,588	2,545,276	9,563,084	451,559	1,774,792	--	--
1914	2,734,043	9,608,041	106,919	415,039	2,138,891	7,354,744	483,203	1,822,770	--	--
1915	1,835,667	5,413,449	83,460	310,850	1,358,611	3,762,239	389,748	1,327,687	--	--
1916	1,982,385	5,896,993	53,047	211,125	1,515,845	4,170,165	409,803	1,500,418	--	--
1917	2,584,287	7,771,084	33,485	138,482	2,022,599	5,464,493	506,679	2,101,040	--	--
1918	2,490,760	8,214,463	37,040	164,650	2,067,230	6,090,106	363,737	1,849,546	--	--
1919	2,271,983	11,591,268	60,823	308,968	1,660,200	7,797,929	524,333	3,347,692	--	--
1920	4,103,982	25,079,572	44,141	367,209	3,369,384	19,464,362	621,396	4,857,399	--	--
1921	2,064,025	12,270,070	---	---	1,780,028	10,431,642	264,159	1,720,819	--	--
1922	2,417,883	10,482,846	1,500	8,250	2,058,593	8,347,522	339,027	2,003,342	--	--
1923	3,006,706	11,576,049	---	---	2,547,653	9,059,427	415,711	2,255,040	--	--
1924	2,867,789	10,252,083	---	---	2,432,581	8,017,476	388,697	1,976,188	--	--
1925	3,481,819	11,545,678	2,147	8,051	2,929,964	8,789,070	464,240	2,334,995	--	--
1926	3,209,976	10,893,800	---	---	2,708,207	8,683,508	455,395	1,980,613	--	--
1927	3,170,699	11,253,352	---	---	2,637,420	8,646,162	481,769	2,318,785	--	--
1928	3,501,406	12,443,179	---	---	2,883,446	9,424,022	577,095	2,856,850	--	--

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Production of Phosphate Rock, by States, Calendar Years, 1900-1928, (Cont'd)

Calendar years	Kentucky		Arkansas		Utah		Montana		Idaho		Wyoming		Western States	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1900			75	$ 225										
1901			—	—										
1902			550	1,650										
1903			2,125	4,600										
1904			—	—										
1905			—	—										
1906			600	1,800					1/	1/			4,500	$27,000
1907			5,572	24,064	1/	1/			1/	1/	1/	1/	6,573	23,034
1908			4,459	19,976	1/	1/			1/	1/	1/	1/	8,651	27,507
1909			4,725	13,900	1/	1/			1/	1/	1/	1/	4,768	15,140
1910			5,600	22,400	1/	1/			1/	1/	1/	1/	9,634	32,819
1911	1/	1/	4,911	22,000	1/	1/			1/	1/	1/	1/	10,505	39,882
1912			3,125	14,000	1/	1/			1/	1/	1/	1/	11,612	49,241
1913			—	—					1/	1/	1/	1/	5,053	18,167
1914			—	—					1/	1/	1/	1/	5,030	15,488
1915			1/	1/	1/	1/			1/	1/	1/	1/	3,837	12,613
1916	1,987	$ 9,935			1/	1/					1/	1/	1,703	5,350
1917	6,428	25,313			1/	1/			1/	1/	1/	1/	15,096	41,756
1918	10,798	68,000			1/	1/			1/	1/			11,955	42,161
1919	9,692	66,824			1/	1/			1/	1/	1/	1/	16,935	69,855
1920	13,452	86,596			1/	1/			1/	1/	1/	1/	55,609	304,006
1921	13,547	91,737					1/	1/	1/	1/	1/	1/	6,291	25,872
1922	14,282	104,040							1/	1/	1/	1/	4,481	19,692
1923	13,007	85,369							1/	1/	1/	1/	30,335	175,713
1924	7,941	63,850					1/	1/	1/	1/	1/	1/	38,570	194,569
1925	12,837	94,064							65,934	$289,498	6,697	$30,000	72,631	319,498
1926	8,797	67,659							33,113	133,020	4,464	29,000	37,577	162,020
1927	-	-							45,260	259,405	6,250	29,000	51,510	288,405
1928	-	-							37,477	147,908	3,388	14,399	40,865	162,307

1/ Bureau of Mines not at liberty to publish these figures without disclosing confidential data; included in totals.

Production of Phosphate Rock, By States, Calendar years, 1900-1928,(Cont'd).

Calendar years	Pennsylvania		Alabama		Other States	
	Long tons	Value	Long tons	Value	Long tons	Value
1900	900	$4,500	334	$534	—	—
1901	893	3,000	—	—	—	—
1902	100	400	—	—	— 70	-$825
1903	—	—	—	—	—	—
1904	100	200	—	—	—	—
1905	—	—	—	—	—	—
1906	—	—	—	—	—	—
1907	—	—	—	—	—	—
1908	—	—	—	—	—	—
1909	—	—	—	—	—	—
1910	—	—	—	—	—	—
1911	—	—	—	—	—	—
1912	—	—	—	—	—	—
1913	—	—	—	—	—	—
1914	—	—	—	—	—	—
1915	—	—	—	—	—	—
1916	—	—	—	—	—	—
1917	—	—	—	—	—	—
1918	—	—	—	—	—	—
1919	—	—	—	—	—	—
1920	—	—	—	—	—	—
1921	—	—	—	—	—	—
1922	—	—	—	—	—	—
1923	—	—	—	—	—	—
1924	—	—	—	—	—	—
1925	—	—	—	—	—	—
1926	—	—	—	—	—	—
1927	—	—	—	—	—	—
1928	—	—	—	—	—	—

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Florida Phosphate Rock Sold or Used by Producers, 1900-1928

Calendar years	Total		Hard rock		Soft rock		Land pebble		River pebble	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1900	706,243	$2,983,312	424,977	$2,229,373	- - -	- - -	221,403	$612,703	59,863	$141,236
1901	751,996	3,159,473	457,568	2,393,080	- - -	- - -	247,454	660,702	46,974	105,691
1902	785,430	2,564,197	429,384	1,743,694	- - -	- - -	350,991	810,792	5,055	9,711
1903	860,336	2,986,824	412,876	1,938,243	- - -	- - -	390,882	885,425	56,578	113,156
1904	1,072,951	3,974,304	531,017	2,672,184	- - -	- - -	460,834	1,102,993	81,030	199,127
1905	1,194,106	4,251,845	577,672	2,993,732	- - -	- - -	528,587	1,045,113	87,847	213,000
1906	1,304,505	5,585,578	587,598	3,440,276	- - -	- - -	675,444	2,029,202	41,463	116,100
1907	1,357,365	6,577,757	646,156	4,065,375	- - -	- - -	675,024	2,376,261	36,185	136,121
1908	1,692,102	8,484,539	595,743	4,566,018	- - -	- - -	1,085,199	3,885,041	11,160	33,480
1909	1,779,702	8,541,301	513,585	4,026,333	- - -	- - -	1,266,117	4,514,968	- - -	- - -
1910	2,067,507	8,647,774	438,347	3,051,827	- - -	- - -	1,629,160	5,595,947	- - -	- - -
1911	2,436,248	9,473,638	443,511	2,761,449	- - -	- - -	1/1,992,737	6,712,189	1/	1/
1912	2,406,899	9,461,297	493,481	3,293,168	- - -	- - -	1/1,913,418	6,168,129	1/	1/
1913	2,545,276	9,563,084	489,794	2,987,274	- - -	- - -	1/2,055,482	6,575,810	1/	1/
1914	2,138,891	7,354,744	309,689	1,912,197	- - -	- - -	1/1,829,202	5,442,547	1/	1/
1915	1,358,611	3,762,239	50,130	265,738	- - -	- - -	1,308,481	3,496,501	- - -	- - -
1916	1,515,345	4,170,165	2/36,412	191,579	2/10,675	104,176	1,468,758	3,874,410	- - -	- - -
1917	2,022,599	5,464,493	3/18,508	3/159,366	3/	3/	2,003,991	5,305,127	- - -	- - -
1918	2,067,230	6,090,106	62,052	377,075	8,331	147,103	1,996,847	5,565,928	- - -	- - -
1919	1,660,200	7,797,929	285,467	2,452,563	14,498	196,318	1,360,235	5,149,048	- - -	- - -
1920	3,369,384	19,464,362	400,249	4,525,191	13,953	190,551	2,955,182	14,748,620	- - -	- - -
1921	1,780,028	10,431,642	175,774	1,806,671	4,419	20,153	1,599,835	8,604,318	- - -	- - -
1922	2,058,593	8,347,522	188,034	1,308,201	446	3,500	1,870,063	7,035,821	- - -	- - -
1923	2,547,653	9,059,427	199,516	1,071,675	- - -	- - -	2,348,137	7,987,752	- - -	- - -
1924	2,432,581	8,017,476	143,115	629,579	- - -	- - -	2,289,466	7,387,397	- - -	- - -
1925	2,929,964	8,789,070	171,649	707,933	- - -	- - -	2,758,315	8,081,137	- - -	- - -
1926	2,708,207	8,683,508	116,264	465,308	- - -	- - -	2,591,943	8,218,200	- - -	- - -
1927	2,637,420	8,646,162	131,254	525,016	- - -	- - -	2,506,166	8,121,146	- - -	- - -
1928	2,383,446	9,424,022	95,918	383,672	- - -	- - -	2,787,528	9,040,350	- - -	- - -
TOTAL	55,071,318	211,757,790	9,425,960	58,993,790	4/52,322	4/ 651,180	4/ 45,166,881	4/ 151,034,577	4/ 426,155	4/ 1,067,622

3/ Soft rock included with hard rock.

1/ A small quantity of River pebble included with land pebble.

2/ Three producers of soft rock reporting, so soft rock and hard rock are shown separately.

4/ Total quantity and value of the different types of rock, only approximate, due to the fact that in some years production of other types of rock have been included.

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TENNESSEE PHOSPHATE ROCK SOLD OR USED BY PRODUCERS, CALENDAR YEARS 1900-1928,

Calendar years	Total		Brown rock		Blue rock		White rock	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1900	454,491	$1,328,707	1/	1/	1/	1/	2/	2/
1901	409,653	1,192,090	1/	1/	1/	1/	2/	2/
1902	390,799	1,206,647	1/	1/	1/	1/	2/	2/
1903	460,530	1,543,567	1/	1/	1/	1/	2/	2/
1904	530,571	1,745,054	1/	1/	1/	1/	2/	2/
1905	482,859	1,633,389	438,139	$1,509,748	44,031	$121,486	689	$2,155
1906	547,677	2,147,991	510,705	2,027,917	35,669	114,997	1,303	5,077
1907	638,612	3,047,836	594,594	2,880,904	38,993	142,382	5,025	24,550
1908	455,431	1,877,221	374,114	1,572,525	79,717	299,941	1,600	4,755
1909	341,115	1,310,529	274,410	1,035,364	66,705	275,165	- - -	- - -
1910	392,588	1,480,950	329,382	1,262,279	63,206	218,671	- - -	- - -
1911	431,566	1,683,267	364,175	1,446,313	67,391	241,954	- - -	- - -
1912	420,206	1,626,476	359,692	1,420,726	60,514	205,750	- - -	- - -
1913	451,559	1,774,392	3/ 451,559	1,774,392	3/	3/	- - -	- - -
1914	483,203	1,822,770	3/ 483,203	1,822,770	3/	3/	- - -	- - -
1915	389,748	1,327,687	3/ 389,748	1,327,687	3/	3/	4/	4/
1916	409,803	1,500,418	362,121	1,347,953	47,682	152,465	- - -	- - -
1917	506,679	2,101,040	440,775	1,895,220	65,904	205,820	- - -	- - -
1918	363,737	1,849,546	363,737	1,849,546	3/	3/	- - -	- - -
1919	524,333	3,347,692	465,783	3,056,741	58,550	290,951	- - -	- - -
1920	621,396	4,857,399	542,725	4,339,165	78,671	518,234	- - -	- - -
1921	264,159	1,720,819	238,996	1,574,621	25,163	146,198	- - -	- - -
1922	339,027	2,003,342	329,949	1,951,539	9,078	51,803	- - -	- - -
1923	415,711	2,255,040	414,792	2,249,393	919	5,647	- - -	- - -
1924	388,697	1,976,188	367,319	1,894,422	21,378	81,766	- - -	- - -
1925	464,240	2,334,995	3/ 464,240	2,334,995	3/	3/	- - -	- - -
1926	455,395	1,980,613	3/ 455,395	1,980,613	3/	3/	- - -	- - -
1927	481,769	2,318,785	3/ 481,769	2,318,785	3/	3/	- - -	- - -
1928	577,095	2,856,850	3/ 577,095	2,856,850	3/	3/	- - -	- - -
TOTAL	13,092,649	57,856,300	5/ 10,074,417	47,730,468	5/ 763,571	3,073,230	5/ 8,617	36,537

3/ Blue rock included with brown rock
4/ Some white rock included with brown rock
2/ No data available as to whether white rock was mined, sold or used in these years.
1/ Rock produced, quantity not known
5/ Total for quantity and value of the different types of rock only approximate due to the fact that in some years production of other types of rock have been included.

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SOUTH CAROLINA PHOSPHATE ROCK, SOLD OR USED BY PRODUCERS, CALENDAR YEARS 1900-1928

Calendar years	Total		Land rock		River rock	
	Long tons	Value	Long tons	Value	Long tons	Value
1900	329,173	$1,041,970	266,186	$877,405	62,987	$164,565
1901	321,181	961,840	225,189	716,101	95,992	245,739
1902	313,365	919,725	245,243	753,220	68,122	166,505
1903	258,540	783,803	233,540	721,303	25,000	62,500
1904	270,806	861,317	258,806	830,117	12,000	31,200
1905	270,225	878,169	234,676	774,447	35,549	103,722
1906	223,675	817,068	190,180	711,447	33,495	105,621
1907	257,221	980,867	228,354	883,965	28,867	96,902
1908	225,495	989,881	192,263	854,837	33,232	135,044
1909	207,954	910,586	201,254	888,611	6,700	21,975
1910	179,659	733,057	1/ 179,659	733,057	2/	2/
1911	169,156	673,156	169,156	673,156	- - -	- - -
1912	131,490	524,760	131,490	524,760	- - -	- - -
1913	109,333	440,588	109,333	440,588	- - -	- - -
1914	106,919	415,039	106,919	415,039	- - -	- - -
1915	83,460	310,850	83,460	310,850	- - -	- - -
1916	53,047	211,125	53,047	211,125	- - -	- - -
1917	33,485	138,482	33,485	138,482	- - -	- - -
1918	37,040	164,650	37,040	164,650	- - -	- - -
1919	60,823	308,968	60,823	308,968	- - -	- - -
1920	44,141	367,209	44,141	367,209	- - -	- - -
1921	- - -	- - -	- - -	- - -	- - -	- - -
1922	1,500	8,250	1,500	8,250	- - -	- - -
1923	- - -	- - -	- - -	- - -	- - -	- - -
1924	- - -	- - -	- - -	- - -	- - -	- - -
1925	2,147	8,051	2,147	8,051	- - -	- - -
1926	- - -	- - -	- - -	- - -	- - -	- - -
1927	- - -	- - -	- - -	- - -	- - -	- - -
1928	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	3,689,835	13,449,411	3/ 3,287,891	3/ 12,315,638	3/ 401,944	3/ 1,133,773

1/ Includes a small quantity of river rock.
2/ A small quantity of river rock, included with land rock.
3/ Totals for quantity and value of the different types of rock, only approximate, due to the fact that in some years production of other types of rock have been included.

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IMPORTS

Import statistics on phosphate rock are available since 1882. During this period the annual shipments of crude phosphate rock into the United States from abroad have ranged between zero in 1918 and a maximum of 175,765 long tons in 1901. Never have they exceeded 50,000 tons, except during the boom years from 1898 to 1905, following the Spanish-American War, when they reached a maximum of 175,765 tons in 1901. From a peak importation of 37,756 long tons in 1885 there was a gradual decline to 8,019 tons in 1897. The effects of the Spanish-American War boom ended in 1906, and between 1906 and 1913 the imports of phosphate rock fluctuated between 11,000 and 29,000 tons. The World War ended the importing of crude phosphates; in 1918 there were no imports and less than a hundred tons in each of the two succeeding years. A recovery was made in the next few years, the imports in 1926 reaching 17,378 tons. In 1927 the first imports of phosphate rock from French Morocco, 10,641 tons, entered the United States, followed in 1928 by even larger quantities (20,572 tons) bringing the total imports of crude phosphate rock in that year up to 45,812 long tons, the highest of any year since import statistics on this commodity have been kept, except for the period of a few years following the Spanish-American War.

The average annual value of the crude phosphate rock imported into the United States has ranged from $4.51 to $33.17 a long ton. An irregular decline in the average annual values started from the peak of $14.13 in 1884 and continued to the Spanish American War boom, during which period the extra large quantities of phosphate rock imported into the United States held the average annual values between $4.51 and $5.77 a ton. Following this the average values rose to and through the World War period reaching $33.17 in 1920 in the post war price boom. There has been an irregular decline since that year in the average annual values which reached $9.41 in 1928, the lowest since 1916.

The imports since 1900 are shown in the accompanying table.

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Phosphate Rock, Crude, Imported For Consumption in the United States 1900 - 1928

(Data from Bureau of Foreign and Domestic Commerce publications)

Years	Quantity, long tons	Value	Average value
1900	137,086	$791,189	$5.77
1901	175,765	872,503	4.96
1902	137,386	646,264	4.70
1903	132,965	679,112	5.11
1904	130,214	745,744	5.73
1905	56,421	275,889	4.89
1906	23,281	147,547	6.34
1907	25,876	163,944	6.34
1908	26,734	175,365	6.56
1909	11,903	97,277	8.17
1910	21,706	235,040	10.83
1911	16,153	157,394	9.74
1912	28,821	231,255	8.02
1913	17,121	124,815	7.29
1914	15,079	136,526	9.05
1915	5,359	50,606	9.44
1916	4,612	36,389	7.89
1917	92	1,169	12.71
1918	- - -	- - -	- - -
1919	34	457	13.44
1920	63	2,090	33.17
1921	3,535	43,960	12.44
1922	5,890	95,846	16.27
1923	6,725	92,263	13.72
1924	16,098	181,515	11.28
1925	2,735	37,932	13.87
1926	17,378	192,611	11.08
1927	28,195	292,871	10.39
1928	45,812	431,238	9.41

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The sources of the imports into the United States since 1924 are given in the following table. The imports from French Oceania were entered for consumption in the Hawaiian Islands and those from Morocco in the eastern United States.

GENERAL IMPORTS

Phosphate Rock Imported into the United States By Countries, 1924-1928

	1924		1925		1926		1927		1928	
	Long tons	Value $	Long tons	Value $	Long tons	Value $	Long tons	Value $	Long tons	Value $
Belgium	- - -	- - -	38	7,836	25	1,120	- - -	- - -	- - -	- - -
Canada	98	865	138	2,606	624	15,057	116	3,222	104	3,284
Cuba	- - -	- - -	2,500	25,000	2,900	30,595	- - -	- - -	11,752	141,544
Dutch W. Ind.	5,500	44,780	- - -	- - -	2,500	23,045	- - -	- - -	13	36
France	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	Less ½ ton	5
French Oceania	10,500	135,870	- - -	- - -	11,329	123,588	17,391	239,855	13,371	183,170
Germany	- - -	- - -	- - -	- - -	- - -	6	45	1,115	- - -	- - -
Japan	- - -	- - -	- - -	- - -	- - -	- - -	2	44	- - -	- - -
French Morocco	- - -	- - -	1	12	- - -	- - -	10,641	48,635	20,572	103,199
United Kingdom	- - -	- - -	58	2,478	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	16,098	181,515	2,735	37,932	17,378	192,611	28,195	292,871	45,812	451,238

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Official figures for the total exports of phosphate rock are available for the years since 1893 and for exports of the different kinds of phosphate rock since 1913. Exports of the various kinds of phosphate rock are available by countries for the fiscal years ended June 30 from 1912 to 1918 and for calendar years from 1915 to the present time.

From 1898 to 1913 exports of phosphate rock increased at a uniform rate. The World War caused a decline in the export trade to about one-tenth of its prewar level. There was a sharp post-war recovery nearly to prewar levels, followed by a decline of about 30 per cent to 1922. From 1922 to 1928 exports have again been increasing at a uniform rate, but this rate is less than that prevailing during the prewar period. In recent years the United States has done little more than hold its own in the world market. Since 1923, exports of American phosphate rock to Europe have actually been declining. Not only has this country not been getting its share of the increased consumption in that market, but it has not even been able to maintain its position there. The gradual increase in the total exports of phosphate rock from the United States is due to its development of new markets, the principal one being Japan.

In 1913, the first year for which official figures for the exports of hard rock are available, exports of that commodity were 473,533 long tons. During the World War, with the absence of many European countries from the market, the exports declined to 12,403 tons in 1917. The post-war recovery brought the exports up to 544,896 long tons in 1920. Since 1920 hard rock exports have declined at a fairly uniform rate to only 89,702 tons in 1928.

Germany is by far the leading consumer of hard rock phosphate exported from the United States, taking in 1928, around 50,000 tons. Belgium, Netherlands, and Sweden, in that year, took around ten thousand tons each. For a considerable period, however, hard rock has been exported to Sweden only every other year.

Prior to the World War land pebble exports had reached 891,263 long tons in 1913. The World War cut the exports to 64,559 tons, but the boom in 1920 brought them up to 693,355 tons. The depression in land pebble exports following this boom culminated in 1922, but the decline was slight, only to 512,777 tons. Since then the annual exports have risen to 809,062 tons in 1928.

Japan has risen to the position of the leading foreign customer of the land pebble industry and takes about 180,000 tons a year. Germany is a close second, and other large customers are Netherlands, Italy and Spain.

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Phosphate ROCK, Ground or Unground, Exported from the the United States, 1898 - 1928
(Data from Bureau of Foreign and Domestic Commerce publications)

Calendar years	High-grade rock		Land pebble		All other		Total	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
1898	- - -	- - -	- - -	- - -	- - -	- - -	570,948	$4,672,463
1899	- - -	- - -	- - -	- - -	- - -	- - -	867,790	6,770,102
1900	- - -	- - -	- - -	- - -	- - -	- - -	619,995	5,217,560
1901	- - -	- - -	- - -	- - -	- - -	- - -	729,539	5,839,245
1902	- - -	- - -	- - -	- - -	- - -	- - -	802,086	6,193,372
1903	- - -	- - -	- - -	- - -	- - -	- - -	785,259	6,109,230
1904	- - -	- - -	- - -	- - -	- - -	- - -	842,484	5,521,555
1905	- - -	- - -	- - -	- - -	- - -	- - -	934,940	7,465,592
1906	- - -	- - -	- - -	- - -	- - -	- - -	904,214	7,373,945
1907	- - -	- - -	- - -	- - -	- - -	- - -	1,018,212	8,387,176
1908	- - -	- - -	- - -	- - -	- - -	- - -	1,188,411	9,294,009
1909	- - -	———	- - -	- - -	- - -	— - -	1,020,556	7,644,368
1910	- - -	- - -	- - -	- - -	- - -	- - -	1,083,037	8,234,276
1911	- - -	- - -	- - -	- - -	- - -	- - -	1,246,577	9,235,388
1912	- - -	- - -	- - -	- - -	- - -	- - -	1,206,520	8,996,456
1913	473,533	$4,735,330	891,263	$5,255,416	1,712	$5,834	1,366,508	9,996,580
1914	281,806	2,818,060	681,241	3,948,079	1,067	5,513	964,114	6,771,652
1915	34,572	331,524	218,472	1,269,659	377	2,668	253,421	1,603,851
1916	28,631	286,948	214,358	863,078	689	6,365	243,678	1,156,391
1917	12,403	113,392	138,010	548,203	15,945	173,450	166,358	835,045
1918	57,771	445,419	64,559	303,758	21,125	163,308	143,455	912,485
1919	215,039	2,261,852	128,860	904,308	34,832	401,822	378,731	3,567,982
1920	344,896	4,496,457	693,355	5,593,814	31,461	479,904	1,069,712	10,570,175
1921	182,594	2,592,541	544,425	4,627,875	6,293	99,721	733,312	7,320,137
1922	202,300	2,548,587	512,777	3,269,179	4,217	40,401	719,294	5,858,167
1923	194,339	2,477,501	630,565	3,273,006	2,647	21,664	827,551	5,772,171
1924	150,746	1,814,194	656,005	3,209,965	12,022	96,673	818,773	5,120,832
1925	158,985	2,283,076	697,891	3,287,370	13,324	107,317	870,200	5,677,763
1926	103,572	1,195,729	634,362	3,155,732	11,029	84,129	748,963	4,435,590
1927	128,774	888,732	1/789,437	3,842,830	1/	1/	918,211	4,731,562
1928	89,702	615,682	1/809,062	3,837,419	1/	1/	898,764	4,453,101

1/ All other included with land pebble.

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928, by Countries (1)

High-Grade Rock

Country	1915		1916		1917		1918	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Australia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Belgium	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
British Honduras	5	$50	- - -	- - -	- - -	- - -	- - -	- - -
Canada	- - -	- - -	336	$3,729	111	$1,375	379	$5,823
Cuba	- - -	- - -	- - -	- - -	45	615	53	860
Denmark	7,700	77,000	- - -	- - -	- - -	- - -	- - -	- - -
England	- - -	- - -	- - -	- - -	- - -	- - -	1,850	9,250
Finland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
France	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Germany	745	7,450	- - -	- - -	- - -	- - -	- - -	- - -
Ireland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Japan	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Mexico	- - -	- - -	- - -	- - -	10	108	- - -	- - -
Netherlands	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
New Zealand	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Nicaragua	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Norway	- - -	- - -	- - -	- - -	8,641	75,336	21,133	145,827
Poland and Danzig	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Portugal	6,423	64,230	- - -	- - -	- - -	- - -	- - -	- - -
Spain	2,908	29,080	3,012	30,120	- - -	- - -	- - -	- - -
Sweden	16,791	153,714	25,283	253,099	3,596	35,958	34,356	283,659
Switzerland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	34,572	331,524	28,631	286,948	12,403	113,392	57,771	445,419

(1) Data from Bureau of Foreign and Domestic Commerce Publications.

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928, By Countries (Cont.

High-Grade Rock

Country	1919		1920		1921		1922		1923	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Australia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Belgium	16,161	$161,610	55,645	$690,705	41,513	$622,695	32,200	$483,000	33,650	$484,950
British Honduras	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Canada	752	14,195	2,226	39,442	6,559	89,262	3,892	47,045	- - -	- - -
Cuba	1,884	21,216	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Denmark	80,753	828,519	58,211	755,655	- - -	- - -	4,400	66,000	- - -	- - -
England	- - -	- - -	8,306	124,587	5,042	78,166	- - -	- - -	U.K. 3,543	28,344
Finland	- - -	- - -	- - -	- - -	- - -	- - -	5,650	74,759	- - -	- - -
France	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Germany	28,062	300,782	104,433	1,407,445	91,880	1,293,893	113,118	1,335,372	134,586	1700,187
Ireland	- - -	- - -	4,600	69,000	- - -	- - -	- - -	- - -	- - -	- - -
Japan	- - -	- - -	4,292	35,076	- - -	- - -	- - -	- - -	- - -	- - -
Mexico	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Netherlands	10,702	134,147	19,522	266,217	25,100	328,900	19,991	258,021	8,140	77,720
New Zealand	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Nicaragua	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Norway	13,517	201,036	30,978	428,865	2,500	38,500	3,200	48,000	- - -	- - -
Poland and Danzig	- - -	- - -	- - -	- - -	10,000	141,125	16,349	183,890	11,420	171,300
Portugal	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Spain	18,527	200,255	24,480	312,845	- - -	- - -	- - -	- - -	3,000	15,000
Sweden	37,106	375,048	32,203	366,620	- - -	- - -	3,500	52,500	- - -	- - -
Switzerland	2,575	25,044	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	215,039	2,261,852	344,896	4,496,457	182,594	2,592,541	202,300	2,548,587	194,339	2477,501

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928 By Countries
(Cont'd.)

High-Grade Rock

Country	1924		1925		1926		1927		1928	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Australia	- - - -	- - - -	- - - -	- - - -	12,500	$187,500	- - - -	- - - -	- - - -	- - - -
Belgium	19,500	$292,500	28,000	$420,000	16,125	219,275	11,950	$81,820	9,000	$63,000
British Honduras	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Canada	- - - -	- - - -	1,490	7,826	2,443	10,734	1,145	6,747	3,559	26,438
Cuba	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Denmark	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
England	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Finland	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
France	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	1,050	7,350	- - - -	- - - -
Germany	92,021	1,031,319	90,374	1,284,285	23,525	232,775	94,725	653,495	49,318	331,419
Ireland	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Japan	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Mexico	- - - -	- - - -	- - - -	- - - -	4	70	- - - -	- - - -	- - - -	- - - -
Netherlands	26,494	355,195	35,221	512,465	12,175	152,225	3,550	24,350	11,425	79,975
New Zealand	- - - -	- - - -	- - - -	- - - -	12,625	136,575	- - - -	- - - -	- - - -	- - - -
Nicaragua	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	4	20	- - - -	- - - -
Norway	- - - -	- - - -	- - - -	- - - -	2,100	36,500	4,200	29,400	2,100	14,700
Poland and Danzig	6,000	90,000	3,900	58,500	8,775	106,925	12,150	85,050	3,600	25,200
Portugal	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Spain	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Sweden	6,731	44,680	- - - -	- - - -	13,300	113,100	- - - -	- - - -	10,700	74,900
Switzerland	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
TOTAL	150,746	1,814,194	158,985	2,283,076	103,572	1,195,729	128,774	888,732	89,702	615,682

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928, By Countries (1)
Land Pebble

Country	1915		1916		1917		1918		1919	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Argentina	- - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
Australia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Belgium	- - -	- - -	- - -	- - -	4,769	$16,930	- - -	- - -	- - -	- - -
British S.Africa	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Canada	2,710	$16,260	2,761	$10,407	5,153	20,036	5,445	$20,991	1,202	$4,807
Cuba	- - -	- - -	4,089	15,620	9,876	31,388	12,063	32,134	8,449	32,857
Czechoslovakia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Denmark	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	17,943	161,776
England	32,501	185,356	23,525	80,543	32,140	127,215	19,804	100,936	27,324	177,993
Ireland)United	31,500	175,000	25,023	94,568	7,500	25,500	- - -	- - -	11,517	75,889
Scotland)Kingdom	14,876	80,290	9,699	37,050	5,100	18,337	- - -	- - -	7,150	82,225
Finland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
France	4,000	24,000	22,073	60,125	8,208	23,124	9,602	48,010	- - -	- - -
Germany	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Greenland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Honduras	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Irish Free State	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Italy	7,964	45,984	6,069	16,387	- - -	- - -	1,440	4,320	- - -	- - -
Japan	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Latvia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Lithuania	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Mexico	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Netherlands	48,374	275,147	27,748	123,046	4,450	20,025	- - -	- - -	26,953	185,256
New Zealand	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Nicaragua	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Norway	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Other Brit.India	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Poland and Danzig	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Portugal	3,500	21,000	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Spain	63,092	336,892	62,179	273,789	60,814	265,648	11,848	73,312	16,072	108,540
Sweden	9,955	59,730	31,192	151,543	- - -	- - -	4,357	24,055	12,250	74,965
Yugoslavia and Albania	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	218,472	1,269,659	214,358	863,078	138,010	548,203	64,559	303,758	128,860	904,308

(1) Data from Bureau of Foreign and Domestic Commerce Publications.

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928, By Countries, (Cont.)

Land Pebble

Country	1920		1921		1922		1923		1924	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Argentina	- - -	- - -	- - -	- - -	- - -	- - -	1,700	$7,650	- - -	- - -
Australia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Belgium	26,788	$216,934	45,160	$389,695	53,793	$309,183	61,434	336,874	38,469	$196,636
British Africa	- - -	- - -	- - -	- - -	3,000	17,250	- - -	- - -	6,620	34,755
Canada	3,854	30,494	146	2,676	9,895	75,028	10,031	54,468	7,019	40,551
Cuba	34,208	262,204	7,055	43,101	3,017	25,073	23,433	83,022	33,672	156,455
Czechoslovakia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Denmark	18,406	192,648	9,062	103,791	54,605	429,984	57,425	330,323	38,072	171,176
England)	154,975	1,277,278	52,924	422,495						
Ireland) United	51,037	395,797	36,713	289,779	U.K.50,698	374,314	U.K.72,997	377,225	U.K.52,087	212,167
Scotland)Kingdom	77,487	574,305	17,438	138,085						
Finland	- - -	- - -	- - -	- - -	- - -	- - -	2,000	14,000	- - -	- - -
France	- - -	- - -	20,380	124,323	27,149	185,121	31,466	180,509	8,798	43,641
Germany	9,129	96,855	79,004	884,135	51,578	283,918	133,948	701,883	129,213	628,143
Greenland	- - -	- - -	- - -	- - -	- - -	- - -	3,685	16,597	- - -	- - -
Honduras	- - -	- - -	3,596	16,182	- - -	- - -	- - -	- - -	- - -	- - -
Irish Free State	- - -	- - -	- - -	- - -	18,716	141,504	20,612	94,303	3,000	9,000
Italy	- - -	- - -	7,352	73,520	- - -	- - -	20,915	96,540	58,419	290,391
Japan	42,516	322,428	20,743	113,799	8,201	31,804	14,225	50,081	45,733	161,423
Latvia	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Lithuania	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Mexico	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Netherlands	70,477	505,512	69,416	558,912	86,218	498,516	67,702	337,371	97,368	472,666
New Zealand	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Nicaragua	- - -	- - -	- - -	- - -	- - -	- - -	3,029	15,931	- - -	- - -
Norway	2,500	22,500	- - -	- - -	- - -	- - -	- - -	- - -	2,000	9,000
Other BritIndies	3,675	25,100	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Poland & Danzig	- - -	- - -	- - -	- - -	- - -	- - -	3,028	20,742	13,366	70,420
Portugal	8,305	55,381	24,545	260,315	- - -	- - -	- - -	- - -	- - -	- - -
Spain	139,066	1,226,670	133,462	1,006,634	122,443	788,027	92,326	492,936	110,146	648,779
Sweden	40,872	339,608	17,429	200,433	17,464	108,457	10,609	62,551	12,023	64,762
Yugoslavia and Albania	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
TOTAL	693,355	$5,593,814	544,425	$4,627,875	512,777	$3,269,179	630,565	$3,273,006	656,005	$3,209,965

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Phosphate Rock, Ground or Unground, Not Acidulated, Exported from the United States, 1915-1928, by Countries,(Cont)

Land Pebble

Country	1925		1926		1927(4)		1928(1)	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Argentina	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Australia	- - -	- - -	36,236	$227,257	27,332	$165,492	- - -	- - -
Belgium	36,731	$184,338	43,551	220,443	20,716	104,186	25,492	$128,313
British So.Africa	21,592	117,456	13,513	75,297	10,380	59,685	- - -	- - -
Canada	12,957	65,987	14,060	74,832	17,848	104,173	18,666	119,519
Cuba	5,825	31,815	14,529	70,754	21,754	106,773	12,157	65,108
Czechoslovakia	- - -	- - -	- - -	- - -	- - -	- - -	3,000	15,300
Denmark	39,783	189,011	69,868	362,541	43,755	193,224	15,947	73,721
England, Ireland) United Scotland)Kingdom	U.K32,214	126,494	U.K.19,275	67,825	U.K.26,492	105,083	U.K. 7,739	29,020
Finland	- - -	- - -	- - -	- - -	9,269	50,426	- - -	- - -
France	3,310	15,343	- - -	- - -	- - -	- - -	- - -	- - -
Germany	92,946	529,072	65,559	338,440	125,661	693,367	166,931	803,549
Greenland	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Honduras	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Irish Free State	3,300	10,725	- - -	- - -	- - -	- - -	- - -	- - -
Italy	69,927	330,373	86,927	439,382	87,612	409,193	96,256	513,526
Japan	95,245	281,401	95,809	343,473	131,137	480,780	183,815	656,839
Latvia	- - -	- - -	- - -	- - -	12,139	63,198	12,206	62,885
Lithuania	- - -	- - -	- - -	- - -	- - -	- - -	3,994	24,963
Mexico	- - -	- - -	- - -	- - -	- - -	- - -	1	14
Netherlands	100,293	475,832	65,373	330,904	127,981	606,491	129,035	636,641
New Zealand	- - -	- - -	6,162	33,891	- - -	- - -	- - -	- - -
Nicaragua	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Norway	3,150	14,375	- - -	- - -	- - -	- - -	- - -	- - -
Other Brit.Indies	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Poland and Danzig	10,900	69,315	3,139	19,776	25,204	155,943	22,337	128,097
Portugal	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Spain	108,485	551,329	94,522	518,802	72,363	369,350	76,051	369,328
Sweden	61,233	294,504	5,839	32,115	29,794	175,466	29,160	178,921
Yugoslavia and Albania	- - -	- - -	- - -	- - -	- - -	- - -	6,275	31,675
	697,891	$3,287,370	634,362	$3,155,732	(1)789,437	$3,842,830	(1)809,062	$3,837,419 (1)

(1) "All other" included with land pebble.

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All Other Phosphate Rock Exported from the United States, Calendar Years 1915 - 1928 [1]

Country	1916		1917		1918		1919		1920		1921	
	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value	Long tons	Value
Australia	- -	- - -	- - -	- - -	- -	- - -	- -	- - -	3	$30	- -	- - -
Barbados	- -	- - -	- -	- - -	- -	- - -	50	$1,375	- - -	- - -	- -	- - -
Belgium	- -	- - -	- -	- - -	- -	- - -	5,554	55,540	- - -	- - -	- -	- - -
Bermuda	- -	- - -	298	$2,905	- -	- - -	- -	- - -	- - -	- - -	- -	- - -
Br. Honduras	- -	- - -	1	9	- -	- - -	1	7	- - -	- - -	- -	- - -
Canada[2]	676	$6,280	5,403	61,205	8,419	$78,888	5,303	70,958	12,955	187,780	4,931	$72,023
China	- -	- - -	- -	- - -	- -	- - -	1	6	- - -	- - -	- -	- - -
Costa Rica	- -	- - -	- -	- - -	- -	- - -	250	1,450	- - -	- - -	- -	- - -
Cuba	- -	- - -	7,555	82,484	4,388	32,337	4,156	74,181	8,134	160,824	1,197	23,635
Denmark	- -	- - -	- - -	- - -	- -	- - -	2,000	36,960	- -	- - -	- -	- - -
Dominican Rep.	- -	- - -	- -	- - -	- -	- - -	- - -	- - -	- -	- - -	- -	- - -
Dutch E. Indies	13	85	- -	- - -	- -	- - -	- - -	- - -	- -	- - -	- -	- - -
England	- -	- - -	- -	- - -	2,525	13,080	- - 1	- - 2	- -	- - -	- -	- - -
Germany	- -	- - -	- -	- - -	- -	- - -	- -	- - -	3,300	51,150	- -	- - -
Honduras	- -	- - -	- -	- - -	- -	- - -	1	28	- -	- - -	22	250
Ireland (U.K.)	- -	- - -	- -	- - -	- -	- - -	- -	- - -	2,500	14,250	- -	- - -
Irish Free St.	- -	- - -	- -	- - -	- -	- - -	- -	- - -	- - -	- - -	- -	- - -
Japan	- -	- - -	- -	- - -	- -	- - -	- -	- - -	1,382	12,737	- -	- - -
Jamaica	- -	- - -	- -	- - -	- -	- - -	75	1,601	- - -	- - -	- -	- - -
Mexico	- -	- - -	1	120	- -	- - -	2	70	- -	- - -	110	2,975
Netherlands	-	- - -	2,182	20,727	- -	- - -	3,500	59,500				
Newfoundland and Labrador	- -	- - -	- -	- - -	- -	- - -	- -	- - -	37	316	23	463
New Zealand	- -	- - -	- -	- - -	- -	- - -	- -	- - -	1	10	- -	- - -
Norway	- -	- - -	- -	- - -	3,975	23,853	2,200	17,607	- -	- - -	- -	- - -
Other British Oceania	- -	- - -	500	6,000	- -	- - -	- -	- - -			1	17
Spain	- -	- - -	- -	- - -	- -	- - -	- -	- - -	3,000	49,500	- -	- - -
Sweden	- -	- - -	- -	- - -	1,818	15,150	11,737	82,527	- -	- - -	- -	- - -
West Indies (Other British)	- -	- - -	- -	- - -	- -	- - -	1	10	149	3,307	9	358
TOTAL	689	6,365	15,945	173,450	21,125	163,308	34,832	401,822	31,461	479,904	6,293	99,721

1 - Data from Bureau of Foreign and Domestic Commerce publications. 1927 and 1928 - All other included with land land pebble.

2 - Only exports in 1915 and 1925 were to Canada. Canada, 1915 - Long tons 377; value $2,668. Canada, 1925 Long tons 13,324; value $107,317

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All Other Phosphate Rock Exported from the United States, Calendar Years 1915-1923, (Cont.)

Country	1922 Long tons	1922 Value	1923 Long tons	1923 Value	1924 Long tons	1924 Value	1926 Long tons	1926 Value
Australia	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Barbados	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Belgium	- -	- - -	- -	- - -	- -	- - -	500	$2,000
Bermuda	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Br. Honduras	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Canada	4,196	$38,281	1,600	17,137	10,941	$80,246	6,649	61,301
China	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Costa Rica	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Cuba	- -	- - -	- -	- - -	81	1,427	---	- - -
Denmark	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Dominican Rep.	- -	- - -	- -	- - -	- -	- - -	60	200
Dutch E. Indies	- -	- - -	- -	- - -	- -	- - -	- -	- - -
England	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Germany	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Honduras	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Ireland (U.K.)	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Irish Free State	19	2,100	- -	- - -	- -	- - -	- -	- - -
Japan	2	20	- -	- - -	- -	- - -	- -	- - -
Jamaica	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Mexico	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Netherlands	- -	- - -	- -	- - -	- -	- - -	3,820	20,628
Newfoundland and Labrador	- -	- - -	29	228	- -	- - -	- -	- - -
New Zealand								
Norway	- -	- - -	- -	- - -	1,000	15,000	- -	- - -
Other British Oceania	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Spain	- -	- - -	- -	- - -	- -	- - -	- -	- - -
Sweden	- -	- - -	1,006	4,024	- -	- - -	- -	- - -
West Indies (Other British)	- -	- - -	12	275	- -	- - -	- -	- - -
TOTAL	4,217	40,401	2,647	21,664	12,022	96,673	11,029	84,129

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CHARACTER OF MARKETED PRODUCT[3]

The content of tricalcium phosphate (B.P.L.) in the grades of phosphate rock marketed in the United States, ranges from as low as 35 per cent to a maximum of 81 per cent. Florida land pebble containing as low as 50 per cent tricalcium phosphate has been marketed for fertilizer filler, and Tennessee brown rock as low as 35 per cent for the same purpose. Some Tennessee brown rock marketed for direct application to the soil contains as low as 65 per cent B.P.L., although much of the rock marketed for this purpose contains over 73 per cent. Some Florida land pebble running between 60 and 65 per cent B.P.L. is marketed for the production of triple superphosphate. Most of the phosphate rock marketed in the United States, however, has a B.P.L. content between 66 and 81 per cent. Tennessee brown rock runs from 70 to 79 per cent B.P.L., and Florida land pebble from 66 to 79 per cent B.P.L. Florida hard rock ranges from 76 to 81 per cent tricalcium phosphate, 77 per cent being about the usual minimum guaranteed. Tennessee blue rock usually contains between 65 and 70 per cent B.P.L., and the western states phosphate rock is stated to contain about 70 per cent.

The number of grades marketed varies considerably in the different fields. In the Florida land pebble area individual companies are placing from one to as many as nine different grades on the market. But one grade is marketed by each of the companies operating in the Florida hard rock field, in the Tennessee blue rock field, and in the western states field. The companies operating in the Tennessee brown rock field usually market but one grade of the brown rock; one company, however, ships several grades.

In most of the phosphate rock marketed in the United States the combined content of iron and aluminum oxides ("I & A") is between 1 and 5½ per cent. It is only in those grades of Tennessee brown rock marketed for direct application to the soil, whose preliminary treatment does not include washing, that the "I & A" content is higher. In these cases it runs from 5 to 11 per cent, but will average between 8 and 9 per cent. The "I & A" content of the Tennessee washed brown rock, which runs from 3 to 5½ per cent, is higher than that of the phosphate rock from any of the other fields, and although some of the Florida land pebble runs as high as 4 per cent, in general, it has a considerably lower content (1 to 4 per cent). The Florida hard rock likewise has a low "I and A" content, 2 to 3 per cent. The combined iron and aluminum oxide in the Tennessee blue rock averages from 1½ to 2 per cent, and in the phosphate rock from the western states, below 3 per cent.

The moisture content in the marketed rock ranges between ½ and 3 per cent. Both the Florida land pebble and the Tennessee brown rock marketed range within these limits. The Florida hard rock contains an average of 1 per cent moisture and the Tennessee blue rock an average of 2 per cent. That marketed from the Western States has less than 1 per cent moisture.

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3 - In this discussion the term "marketed product" refers to the material shipped from the producer to the consuming plant, whether that plant belongs to the producing company or to an independent consumer.

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The size of the phosphate rock marketed in the United States, other than the lump rock, ranges from a maximum of 1½ to 2 inches down to fine water-settled material. The Florida hard rock has a maximum size of about 1½ inches, and a minimum of 1/16 inch. The land pebble has a similar maximum and a lower limit of 1 millimeter. The Tennessee brown rock sizes range from about 1½ or 2 inches down to fine water settled sands. The Tennessee blue rock is crushed to 1/2 inch, and then screened to sizes ranging from 1/4 to over 2 inches. In Idaho, one producer crushes to below 3/4 inch before shipping, whereas the other ships mine-run material. The Wyoming rock is finely ground, 65 per cent to pass a 200-mesh screen. Some Tennessee and Florida rock is also finely ground, some of the brown rock in Tennessee fine enough so that much of it passes a 300 mesh screen. Lump rock is marketed from Tennessee and the Western States. The Tennessee brown rock yields up to 10 to 12 inch lumps, but the blue rock of that State is crushed to 4 inches before marketing.

PRICES

Prices of phosphate rock are quoted in dollars per ton on an even percentage of B.P.L. (bone phosphate of lime - equivalent tricalcium phosphate), such as 75, 76, or 78, with allowances for "I and A" (iron oxide and alumina) within certain limits. Allowances are also made for variations from this base grade, as when a price is based on 75 per cent B.P.L., and it is guaranteed that the rock shall not run less than 74 per cent. Penalties are, however, exacted for units below 75 per cent, and bonuses paid for units above it. Prices for all but Tennessee ground rock are quoted in long tons. Tennessee ground rock for direct application to the soil is quoted in short tons.

Price basing point is usually the mine, producing plant, or nearest shipping point, and the quotations are f.o.b. In Florida hard rock export quotations are now said to be practically all made c.i.f. destination in Europe, although domestic trade journals quote prices at mines, and foreign journals prices at United States port of shipment.

The following tables taken from the Federal Trade Commission report on the fertilizer industry, published in 1922, give the high, low, and mean prices per gross ton at the mines for Florida land pebble phosphate for the period from 1907 to 1914, and of Tennessee rock for the period 1910 to 1914. These figures show the price situation before the World War. These prices were taken by the Commission from the contracts of mining companies for sales to domestic purchasers. All sales were taken, since prompt transactions in phosphate rock are rare. The range of contract prices by months rather than the average is given because of the comparatively small number of sales.

In these tables a marked difference in the price trend in Florida and Tennessee is noticeable. The prices of Florida land pebble phosphate at the mines show in general a gradual downward trend. In 1907 Florida land pebble is said to have sold above $7 a ton. The highest price shown in the table for 1908 was $4.65, and the lowest $3 a ton. In the first half of 1914 the highest price was $2.75, and the lowest $2 a ton, which was less than the actual cost of production of some of the mines. After July 1, 1914, sales below $2 a ton for the 68 per cent grade occurred. The mean prices of Tennessee rock given in the table show a gradual upward trend since 1910.

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The decline in the prices of the Florida land pebble phosphate rock during the years from 1907 to 1914 was due to overproduction. The stability of the Tennessee phosphate rock prices has been due mainly to the much smaller quantity mined and the advantage of location with respect to the Central States.

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High, low, and mean contract prices per gross ton of Florida land pebble phosphate rock, at mines, by months, 1908-1914 (68 to 70 per cent grades unless otherwise noted)

Year		Months											
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1908-	High	$----	$4.65	$3.75	$3.50	$3.50	$3.50	$3.50	$3.25	$3.30	$3.25	$3.75	$3.00
	Low	----	3.50	3.25	3.25	3.25	3.00	3.00	3.10	3.30	3.00	3.00	3.00
	Mean	----	4.08	3.50	3.38	3.38	3.25	3.25	3.18	3.30	3.13	3.38	3.00
1909	High	----	3.00	3.00	3.50	2.92	(1) 3.31	----	3.25	4.25	2.88	(1) 3.77	(1) 3.04
	Low	----	2.85	2.85	(1) 2.78	(1) 2.72	(1) 2.79	----	3.00	2.85	2.75	3.00	2.80
	Mean	----	2.93	2.93	3.14	2.82	(1) 3.05	----	3.13	3.55	2.81	3.39	2.92
1910	High	3.00	----	(1) 3.24	(1) 3.53	2.75	(1) 3.62	3.25	3.60	3.25	3.25	(1) 3.64	3.25
	Low	2.85	----	3.00	(1) 3.32	2.75	2.95	2.75	2.75	2.25	2.75	(1) 3.07	2.75
	Mean	2.93	----	3.12	(1) 3.43	2.75	3.29	3.00	3.18	2.75	3.00	(1) 3.36	3.00
1911	High	3.25	3.25	3.25	3.25	3.25	3.25	3.80	3.25	3.25	3.25	(1) 3.26	3.25
	Low	3.25	3.75	2.75	2.75	2.75	3.25	2.90	2.75	2.75	2.75	(1) 3.03	2.85
	Mean	3.25	3.00	3.00	3.00	3.00	3.25	3.35	3.00	3.00	3.00	(1) 3.15	3.05
1912	High	(1) 3.49	3.25	(1) 3.25	(1) 3.07	3.25	3.30	2.80	2.80	2.80	2.80	2.80	2.80
	Low	2.70	2.85	2.75	(1) 2.74	2.65	2.75	2.70	2.70	2.80	2.80	2.80	2.50
	Mean	3.10	3.05	3.00	(1) 2.91	2.95	3.13	2.75	2.75	2.80	2.80	2.80	2.65
1913	High	2.75	2.80	2.75	2.98	(1) 2.94	2.75	2.75	2.75	2.75	2.75	2.75	2.75
	Low	2.75	2.75	2.50	2.40	2.65	2.25	2.25	2.25	(1) 2.55	2.75	2.00	2.00
	Mean	2.75	2.78	2.63	2.69	2.80	2.50	2.50	2.50	2.65	2.75	2.38	2.38
1914	High	2.75	2.15	2.00	2.20	----	2.00	----	----	-------	-----	----	-----
	Low	2.00	2.15	2.00	2.00	-----	2.00	----	----	-------	----	----	-----
	Mean	2.38	2.15	2.00	2.10	-----	2.00	----	----	-------	----	----	-----

(1) 70 to 74 per cent grade.

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High, low, and mean contract prices per gross ton of Tennessee brown phosphate rock, at mines, by months, 1910-1914 (72 to 75 per cent grades)

Year		Months											
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910-	High	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50	$4.00	$4.30	$4.00	$4.10	$4.00	$4.00
	Low	3.00	3.35	3.00	3.00	3.35	3.35	3.00	3.35	3.00	3.00	3.00	3.00
	Mean	3.25	3.43	3.25	3.25	3.43	3.43	3.50	3.83	3.50	3.55	3.50	3.50
1911	High	4.00	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.00	4.00	4.10	4.10
	Low	3.00	3.00	3.50	3.50	3.50	3.00	3.00	3.00	3.00	3.00	3.50	3.00
	Mean	3.50	3.55	3.80	3.80	3.80	3.55	3.55	3.55	3.50	3.50	3.80	3.55
1912	High	4.30	4.25	4.25	4.25	4.50	4.25	4.25	4.25	4.25	4.25	4.25	4.25
	Low	3.00	4.25	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Mean	3.65	4.25	3.63	3.63	3.75	3.63	3.63	3.63	3.63	3.63	3.63	3.63
1913	High	4.30	4.25	4.25	4.25	4.25	4.25	4.00	4.00	3.60	4.00	4.00	4.00
	Low	3.00	3.50	3.50	3.00	3.50	3.00	3.60	4.00	3.60	3.60	3.60	3.60
	Mean	3.65	3.88	3.88	3.63	3.88	3.63	3.80	4.00	3.60	3.80	3.80	3.80
1914	High	4.25	4.25	4.25	4.25	4.25	4.25	-	-	-	-	-	-
	Low	3.00	3.50	3.00	3.50	4.10	4.00	-	-	-	-	-	-
	Mean	3.63	3.88	3.63	3.85	4.18	4.13	-	-	-	-	-	-

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No tables similar to those prepared by the Federal Trade Commission for the immediate prewar years are available for the war period, or the post-war years. Low prices occurred in the early war years. Prices rose to high levels in the post-war boom, climaxing in the latter part of 1920 and the early part of 1921. The succeeding decline in prices continued until 1926. There has been a slight rise since. The major trends during the period from 1923 to 1928 are indicated in the prices of Florida land pebble phosphate rock, 70 per cent tri-calcium phosphate, given in the accompanying table compiled from Engineering and Mining Journal quotations.

MONTHLY PRICES OF FLORIDA LAND PEBBLE PHOSPHATE ROCK, DOMESTIC, 70 PER CENT

Year	1923	1924 1/	1925	1926	1927	1928
January	$4.50	$4.25	$3.30	$3.00	$3.50	$3.50
February	4.50	4.00	3.35	3.00	3.50	3.50
March	4.35	3.80	3.50	3.25	3.75	3.50
April	4.35	3.80	3.50	3.50	3.50	3.50
May	4.35	3.80	3.25	3.50	3.50	3.50
June	4.35	3.50	3.50	3.50	3.50	3.50
July	4.35	3.50	3.50	3.50	3.50	4.00
August	4.35	3.50	3.50	3.50	3.50	4.00
September	4.35	3.50	3.50	3.50	3.50	4.00
October	4.25	3.50	3.40	3.50	3.50	4.00
November	4.25	3.50	3.40	3.50	3.50	4.00
December	4.25	3.35	3.50	3.50	3.50	4.00
Average	4.35	3.66	3.43	3.39	3.52	3.75
High	4.50	4.25	3.50	3.50	3.75	4.00
Low	4.25	3.35	3.25	3.00	3.50	3.50

Remarks. - 1/ Florida export prices. Data from Eng. Min. Jour.

Quotations for certain grades of Florida and Tennessee rock are given regularly in the trade journals. Western rock prices are not quoted, as the rock in that field is mostly produced by the mining companies for their own use in manufacturing other production and does not come on the market except as finished products.

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CONSUMPTION OF PHOSPHATE ROCK IN THE UNITED STATES

The consumption of phosphate rock in the United States has grown from about 1,000,000 tons in 1900 to 2,600,000 tons in 1928. The rate of growth was fairly uniformly upward until 1911. The succeeding three years saw a slight downward trend in the consumption, which lasted until the opening of the World War. The start of this conflict at first resulted in a rather sharp further decline in 1915 in the consumption of phosphate rock in the United States, but with the insistent demand for greater production of foodstuffs this was followed by the boom during the later part of the war period, 1916 to 1918, inclusive, when the consumption of phosphate rock increased at a rapid rate and reached new high levels. In the general disorganization following the close of the war there was a marked decline in the consumption of phosphate rock in the United States, and the consumption in 1919 returned nearly to pre-war levels. Recovery from this depression soon occurred, however, and at the crest of the post-war inflationary period in 1920, the consumption of phosphate rock in the United States exceeded 3 million tons, an amount much greater than had been consumed in any previous year, and which has not been even closely approached since. The collapse of business and the resulting depression in 1921 severely hit the phosphate rock consuming industries, and the domestic consumption of phosphate rock was reduced over 300,000 to about 1,300,000 tons, the lowest annual consumption since 1909. In recovering from this depression the annual consumption reached 2,600,000 tons in 1928.

The table accompanying this section shows the annual apparent consumption of phosphate rock in the United States and also the annual consumption of domestic phosphate rock during the past ten years. There is comparatively little difference in the two sets of figures as imports are as yet relatively small, the home demand being largely satisfied from domestic production.

Consumption of Phosphate Rock in the United States
(Long tons)

Years	Marketed Production	Imports	Exports	Apparent Consumption Total	Apparent Consumption Domestic Rock
1919	2,271,983	34	378,731	1,893,286	1,893,252
1920	4,103,982	63	1,069,712	3,034,333	3,034,270
1921	2,064,025	3,535	733,313	1,334,248	1,330,713
1922	2,417,883	5,890	719,294	1,704,479	1,698,589
1923	3,006,706	6,725	827,551	2,185,880	2,179,155
1924	2,867,789	16,093	818,773	2,065,114	2,049,016
1925	3,431,819	2,735	870,200	2,614,354	2,611,619
1926	3,209,976	17,378	748,963	2,478,391	2,461,013
1927	3,170,699	28,195	918,211	2,230,683	2,252,488
1928	3,457,339	45,812	898,764	2,604,387	2,558,575

1/ Apparent total consumption equals marketed production plus imports minus exports.

2/ Consumption of domestic rock equals marketed production minus exports.

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LIST OF CONSUMERS OF PHOSPHATE ROCK, BY USES

The following list of consumers of phosphate rock has been classified according to the principal phosphate containing products produced by the different companies from phosphate rock. Consumers of phosphate rock for direct application to the soil are not listed, and there has not been any attempt to list the consumers for production of by-products such as sodium silicofluoride, or for some of the smaller uses such as concrete aggregate, road metal, and fillers for various purposes. This list has been compiled through the cooperation of both the producers and consumers of phosphate rock and others interested in the phosphate rock industry. The list of iron furnaces using phosphate rock was obtained through the hearty cooperation of the iron and steel companies of this country. Some of the names of the superphosphate producing companies were obtained from the American Fertilizer Handbook; others by correspondence with the superphosphate companies.

CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF SUPERPHOSPHATES

Acme Manufacturing Co., Wilmington, N. C.
Alabama Chemical Co., Montgomery, Ala.
American Agricultural Chemical Co., 420 Lexington Ave., New York, N. Y.
Anaconda Copper Mining Co., Fertilizer Dept., 111 West Washington Street, Chicago, Ill.
Anderson Fertilizer Co. (Inc.), Anderson, S. C.
Arkansas Fertilizer Co., Little Rock, Ark.
Armour Fertilizer Works, 111 West Jackson Boulevard, Chicago, Ill.
Barker Chemical Co., Savannah, Ga.
Baugh & Sons Co., 20 South Delaware Avenue, Philadelphia, Pa.
Baugh Chemical Co., 25 South Calvert Street, Baltimore, Md.
Blackshear Manufacturing Co., Blackshear, Ga.
Brown Guano Co., D., Albany, Ga.
Calumet Fertilizer Corporation, 61 Broadway, New York, N. Y.
Capital City Acid Phosphate Co., Little Rock, Ark.
Capital Fertilizer Co., Montgomery, Ala.
Caraleigh Phosphate Fertilizer Works, Raleigh, N. C.
Catawba Fertilizer Co., Lancaster, S. C.
Central Chemical Co., Hagerstown, Md.
Chickamauga Fertilizer Works, Atlanta, Ga.
Columbus Fertilizer Co., Columbus, Ga.
Congaree Fertilizer Co., Palmetto Building, Columbia, S. C.
Contentnea Guano Co., Wilson, N. C.
Cotton States Fertilizer Co., Macon, Ga.
Darling & Co., 4201 South Ashland Avenue, Chicago, Ill.
Davison Chemical Co., Garrett Building, Baltimore, Md.
Davison-Pick Fertilizers (Inc.), New Orleans, La.
Diamond Fertilizer Co., Commercial Bank Building, Sandusky, Ohio.
Dixie Guano Co., Laurinburg, N. C.
Dockwiler & Kingsbury Co., East Thirtieth and Emerson Avenue, Indianapolis, Ind.
Empire State Chemical Co., Athens, Ga.

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Etiwan Fertilizer Co., Charleston, S. C.
Farmers' Fertilizer Co., Windsor Avenue, and Cleveland, Akron & Cincinnati Railroad, Columbus, Ohio.
Farmers' Guano Co., Norfolk, Va.
Federal Chemical Co., Fourth and Broadway, Louisville, Ky.
Furman Fertilizer Works, Atlanta, Ga.
Georgia Fertilizer Co., Valdosta, Ga.
Grasselli Chemical Co., Birmingham, Ala.
Griffith & Boyd Co., Keyser Building, Baltimore, Md.
Groves Fertilizer Works, Cincinnati, Ohio.
Gulfport Fertilizer Co., Gulfport, Miss.
Hamm Company, M., Washington Court House, Ohio.
Hartsville Fertilizer Co., Hartsville, S. C.
Home Guano Co., Dothan, Ala.
International Agricultural Corporation, 61 Broadway, New York, N. Y.
Jackson Fertilizer Co., Jackson, Miss.
Jarecki Chemical Co., 111 West Jackson Boulevard, Chicago, Ill.
Josey Guano Co., N. B., Wilmington, N. C.
King Chemical Co., Bound Brook, N. J.
Knoxville Fertilizer Co., Bankers Trust Building, Knoxville, Tenn.
Laurel Oil & Fertilizer Co., Laurel, Miss.
Lowell Fertilizer Co., Boston, Mass.
McCabe Fertilizer Co., Charleston, S. C.
Mandeville Mills, Carrollton, Ga.
Maybank Fertilizer Co., Charleston, S. C.
Merchants Fertilizer & Phosphate Co., Charleston, S. C.
Meridian Fertilizer Factory, Citizens National Bank Building, Meridian, Miss.
Miller Fertilizer Co., Garrett Building, Baltimore, Md.
Montezuma Fertilizer Co., Montezuma, Ga.
Morris Fertilizer Co., Chicago, Ill.
Mountain Copper Co. (Ltd.) 532 Pine Street, San Francisco, Calif.
Mutual Fertilizer Co., Savannah, Ga.
Ober & Sons Co., G., 110 East Lombard Street, Baltimore, Md.
Pacific Guano and Fertilizer Co., Matson Building, San Francisco, Calif.
Pelham Phosphate Co., Pelham, Ga.
Pennsylvania Salt Manufacturing Co., Widener Building, Philadelphia, Pa.
Piedmont-Mt. Airy Guano Co., Keyser Building, Baltimore, Md.
Pittsburgh Provision & Packing Co., Herrs Island, Pittsburgh, Pa.
Planters' Chemical and Oil Co., Talladega, Ala.
Planters' Fertilizer and Phosphate Co., Charleston, S. C.
Porter Fertilizer Works, Atlanta, Ga.
Powhatan Fertilizer Co., Greenville, S. C.
Rauh & Sons Fertilizer Co., E., Union Stock Yards, Indianapolis, Ind.
Read Phosphate Co., Savannah, Ga.
Reading Bone Fertilizer Co., Reading, Pa.
Redd Chemical and Nitrate Co., Birmingham, Ala.
Reliance Fertilizer Co., Savannah, Ga.
Richmond Guano Co., Richmond, Va.
Roanoke Guano Co., Roanoke, Ala.
Robertson Chemical Corporation, Norfolk, Va.
Royster Guano Co., F. S., Norfolk, Va.

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Shreveport Fertilizer Works, Shreveport, La.
Smith Agricultural Chemical Co., Columbus, Ohio.
Southern Agricultural Chemical Corporation, 61 Broadway, New York, N. Y.
Southern Fertilizer & Chemical Co., Savannah, Ga.
Southern States Phosphate and Fertilizer Co., Augusta, Ga.
Standard Chemical Co., Troy, Ala.
Standard Fertilizer Co., Gainesville, Fla.
Standard Wholesale Phosphate & Acid Works (Inc.), Continental Building, Baltimore, Md.
Summers Fertilizer Co. (Inc.), Stock Exchange Building, Baltimore, Md.
Swift & Co., Union Stock Yards, Chicago, Ill.
Talladega Fertilizer Manufacturing Co., Talladega, Ala.
Tennessee Chemical Co., Nashville, Tenn.
Thomas & Son Co., I. P., Drexel Building, Philadelphia, Pa.
Tunnell & Co., F. W., (Inc.), 15 North Fifth Street, Philadelphia, Pa.
United States Phosphoric Products Corporation, Tampa, Fla.
Virginia-Carolina Chemical Corporation, 11 South Twelfth Street, Richmond, Va.
Welch Chemical Co., Columbus, Ohio.
Wilson & Toomer Fertilizer Co., 772 West Bay Street, Jacksonville, Fla.
Wuichet Fertilizer Co., Dayton, Ohio.
Wulbern Fertilizer Co., Charleston, S. C.
York Chemical Works, York, Pa.

CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF DICALCIUM PHOSPHATE FERTILIZERS

Myles Salt Co. (Ltd.), 1007 Camp Street, New Orleans, La.

CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF FERROPHOSPHORUS

Chio Ferro-Alloys Corporation, Canton, Ohio.
Oldbury Electro-Chemical Co., Niagara Falls, N. Y.
Federal Phosphorus Co., Birmingham, Ala.
Tennessee Products Corporation, Nashville, Tenn.
Victor Chemical Works, 343 South Dearborn Street, Chicago, Ill.
Warner Iron Co., Nashville, Tenn.

CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF PHOSPHORIC ACID

Anaconda Copper Mining Co., Anaconda, Mont.
Bowker Chemical Co., 419 Fourth Ave, New York, N. Y.
Federal Phosphorus Co., Birmingham, Ala.
International Agricultural Corporation, 61 Broadway, New York, N. Y.
Phosphate Products Corporation, Richmond Trust Building, Richmond, Va.
Provident Chemical Works, Planters Building, St. Louis, Mo.
Rumford Chemical Works, Rumford, R. I.
Victor Chemical Works, 343 South Dearborn Street, Chicago, Ill.
Virginia-Carolina Chemical Corporation, 11 South Twelfth Street, Richmond, Va.

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Warner Chemical Co., 415 Lexington Avenue, New York, N. Y.
Wilckes-Martin-Wilckes Co., 135 William Street, New York, N. Y.

CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF PHOSPHATE CHEMICALS

American Cyanamid Co., 535 Fifth Avenue, New York, N. Y.
(Monoammonium phosphate, disodium phosphate, and trisodium phosphate.)

Anaconda Copper Mining Co., Anaconda, Mont.
(Ammonium phosphates.)

Blockson Chemical Co., Joliet, Ill.
(Ammonium phosphate, disodium phosphate, trisodium phosphate.)

Bowker Chemical Co., 419 Fourth Avenue, New York, N. Y.
(Disodium phosphate and trisodium phosphate.)

Calumet Chemical Co., Joliet, Ill.
(Monocalcium phosphate and dicalcium phosphate.)

Federal Phosphorus Co., Birmingham, Ala.
(Monoammonium phosphate, diammonium phosphate, monosodium phosphate, disodium phosphate, trisodium phosphate, acid sodium phosphate, monocalcium phosphate, dicalcium phosphate, tricalcium phosphate.)

General Chemical Co., 40 Rector Street, New York, N. Y.
(Disodium phosphate and trisodium phosphate.)

Grasselli Chemical Co., Guardian Building, Cleveland, Ohio.
(Disodium phosphate and trisodium phosphate.)

International Agricultural Corporation, 61 Broadway, New York, N. Y.
(Ammonium phosphate, disodium phosphate, and trisodium phosphate.)

Phosphate Products Corporation, Richmond Trust Building, Richmond, Va.
(Ammonium phosphate; calcium acid phosphate, sodium phosphate.)

Provident Chemical Works, Planters Building, St. Louis, Mo.
(Monocalcium phosphate, dicalcium phosphate, tricalcium phosphate, acid calcium phosphate, pyrocalcium phosphate, pyrosodium phosphate, trisodium phosphate.

Rumford Chemical Works, Rumford, R. I.
(Monocalcium phosphate, dicalcium phosphate, and tricalcium phosphate.)

Victor Chemical Works, 343 South Dearborn Street, Chicago, Ill.
(Monoammonium phosphate, diammonium phosphate, monocalcium phosphate, dicalcium phosphate, tricalcium phosphate, monosodium phosphate, disodium phosphate, trisodium phosphate, and acid pyrosodium phosphate.)

Virginia-Carolina Chemical Corporation, 11 South Twelfth Street, Richmond, Va.
(Monocalcium phosphate.)

Warner Chemical Co., 415 Lexington Avenue, New York, N. Y.
(Monosodium phosphate, disodium phosphate, and trisodium phosphate.)

Wilckes-Martin-Wilckes Co., 135 William Street, New York, N. Y.
(Monoammonium phosphate, diammonium phosphate, sodium ammonium phosphate, monocalcium phosphate, dicalcium phosphate, tricalcium phosphate, and potassium phosphate.)

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CONSUMERS OF PHOSPHATE ROCK FOR THE MANUFACTURE OF PHOSPHORUS

Oldbury Electro-Chemical Co., Niagara Falls, N. Y.

CONSUMERS OF PHOSPHATE ROCK FOR PRODUCTION OF STOCK AND POULTRY FEED

Moorman Manufacturing Co., Quincy, Ill.
Myles Salt Co. (Ltd.), 1007 Camp Street, New Orleans, La.
Vitamineral Products Co., Peoria, Ill.

IRON AND STEEL COMPANIES USING PHOSPHATE ROCK OCCASIONALLY OR AS STANDARD PRACTICE

Alan Wood Iron & Steel Co., Widener Building, Philadelphia, Pa.
American Rolling Mill Co., Middletown, Ohio.
Antrim Iron Co., Grand Rapids, Mich.
Bethlehem Steel Co., Bethlehem, Pa.
E. & G. Brooke Iron Co., Birdsboro, Pa.
Cleveland-Cliffs Iron Co., 1460 Union Trust Building, Cleveland, Ohio.
Colonial Iron Co., 149 Broadway, New York, N. Y.
Columbia Steel Corporation, 215 Market Street, San Francisco, Calif.
Corrigan, McKinney Steel Co., 3100 East Forty-fifth Street, Cleveland, Ohio.
Delaware River Steel Co., Chester, Pa.
Delta Chemical and Iron Co., Wells, Mich.
Hamilton Coke & Iron Co., Hamilton, Ohio.
Hanna Furnace Co., 1300 Leader Building, Cleveland, Ohio.
Inland Steel Co., 38 South Dearborn Street, Chicago, Ill.
International Harvester Co., 606 South Michigan Avenue, Chicago, Ill.
Jackson Iron & Steel Co., Jackson, Ohio.
Marting Iron & Steel Co., Ironton, Ohio.
Perry Iron Co., Union Trust Building, Cleveland, Ohio.
Pulaski Iron Co., Pulaski, Va.
Reliance Coke & Furnace Co., 514 Frick Building, Pittsburgh, Pa.
St. Louis Gas & Coke Corporation, Box 364, Granite City, Ill.
Shenango Furnace Co., Oliver Building, Pittsburgh, Pa.
Sloss-Sheffield Steel & Iron Co., Birmingham, Ala.
Superior Steel and Malleable Castings Co., Benton Harbor, Mich.
Toledo Furnace Co., Union Trust Building, Cleveland, Ohio.
Warren Foundry & Pipe Corporation, Wharton, N. J.
Youngstown Sheet & Tube Co., Youngstown, Ohio.
Zenith Furnace Co., West Duluth, Minn.

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GEOGRAPHICAL DISTRIBUTION OF DOMESTIC CONSUMPTION

Probably at least 95 per cent of the phosphate rock consumed in the United States is used east of the Mississippi River. The consumption of phosphate rock for the manufacture of the superphosphates is almost entirely east of the Mississippi River with a marked concentration in the Southern Atlantic States, a large part of the superphosphate produced being used on the cotton and tobacco crops. Isolated plants using Western States phosphate rock are located in Montana and California.

Consumption of phosphate rock for other purposes than the manufacture of the superphosphates is likewise largely in the eastern part of the United States. The only producer of elemental phosphorus is located at Niagara Falls, N.Y. The ferrophosphorus producers are in Alabama, Tennessee, Ohio and New York. Plants producing phosphoric acid from phosphate rock all lie on or east of the Mississippi River, except for one plant in Montana. Blast furnaces using phosphate rock in furnace charges in the production of pig iron are all located east of the Mississippi River and north of the Ohio and Potomac Rivers, save for isolated plants in Alabama, Virginia, and Utah. The latter plant uses Western States phosphate rock. All others get their phosphate rock from Tennessee. Finely ground phosphate rock for direct application to the soil is produced principally in Tennessee and is used most extensively in Illinois. A small amount of finely ground Idaho and Wyoming phosphate rock is used in the Western States.

DISTRIBUTION OF DOMESTIC CONSUMPTION BY INDUSTRIES

No studies are available as to the amounts of phosphate rock consumed for different purposes. However, an indication of the quantities utilized by the principal consuming industries can be obtained by the published statistics on the sales of phosphate rock by producers for different purposes. Data available for such sales in 1928 indicate that 90 per cent of the rock sold in the United States was for use in the preparation of ordinary and treble superphosphates, principally the former. Second in importance were those sales to those industries engaged in the manufacture of elemental phosphorus, phosphoric acid, ferrophosphorus, and pig iron. Sales to this group comprised 7.8 per cent of the total sales. The statistical data available do not permit the separation of the sales for the various industries specified in this group. Sales of finely ground phosphate rock for direct application to the soil took 1.6 per cent of the total sales, while the balance, 0.6 per cent, was distributed among diverse uses.

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